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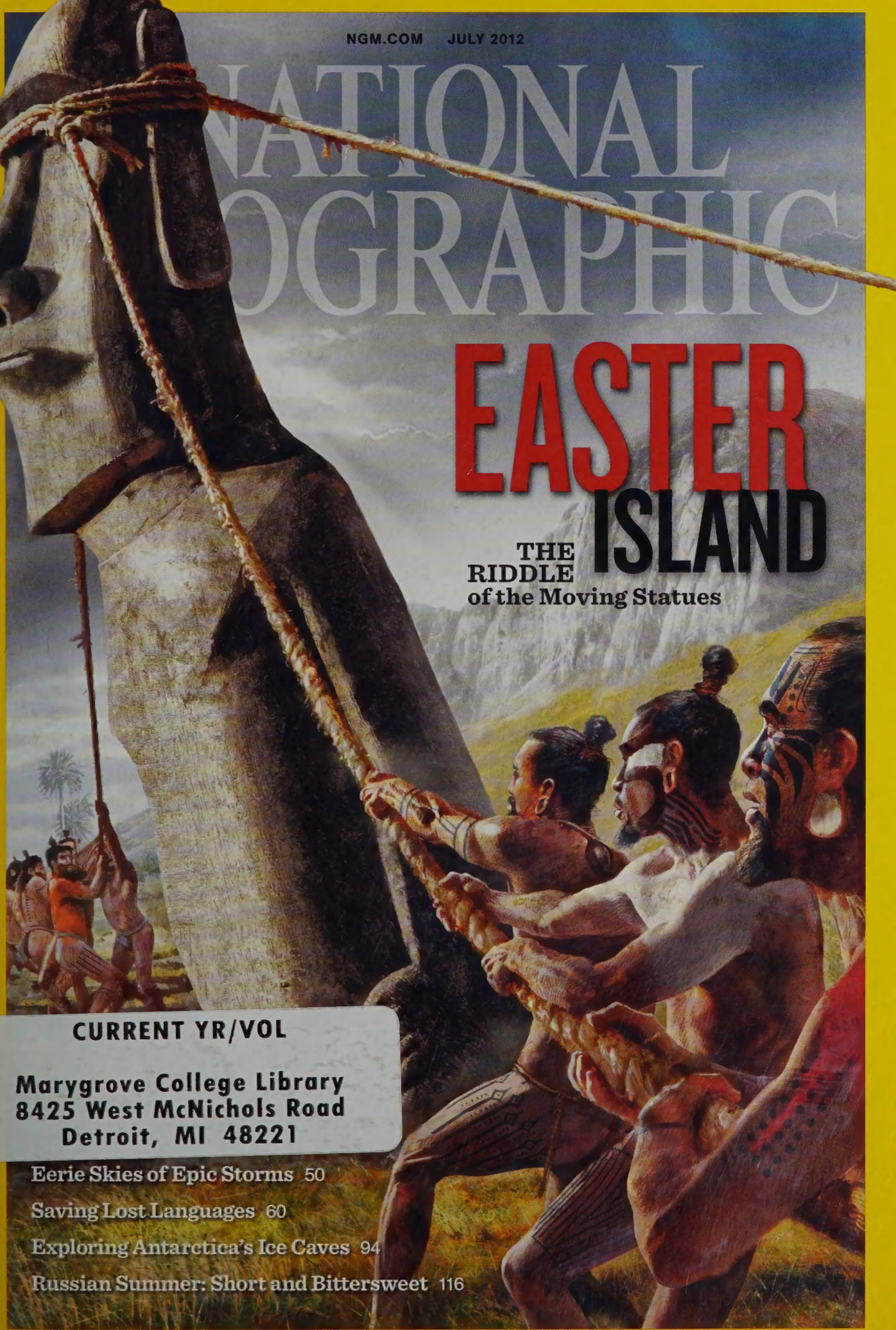

# EASTER ISLAND

## THE RIDDLE of the Moving Statues

CURRENT YR/VOL

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Eerie Skies of Epic Storms 50

Saving Lost Languages 60

Exploring Antarctica's Ice Caves 94

Russian Summer: Short and Bittersweet 116

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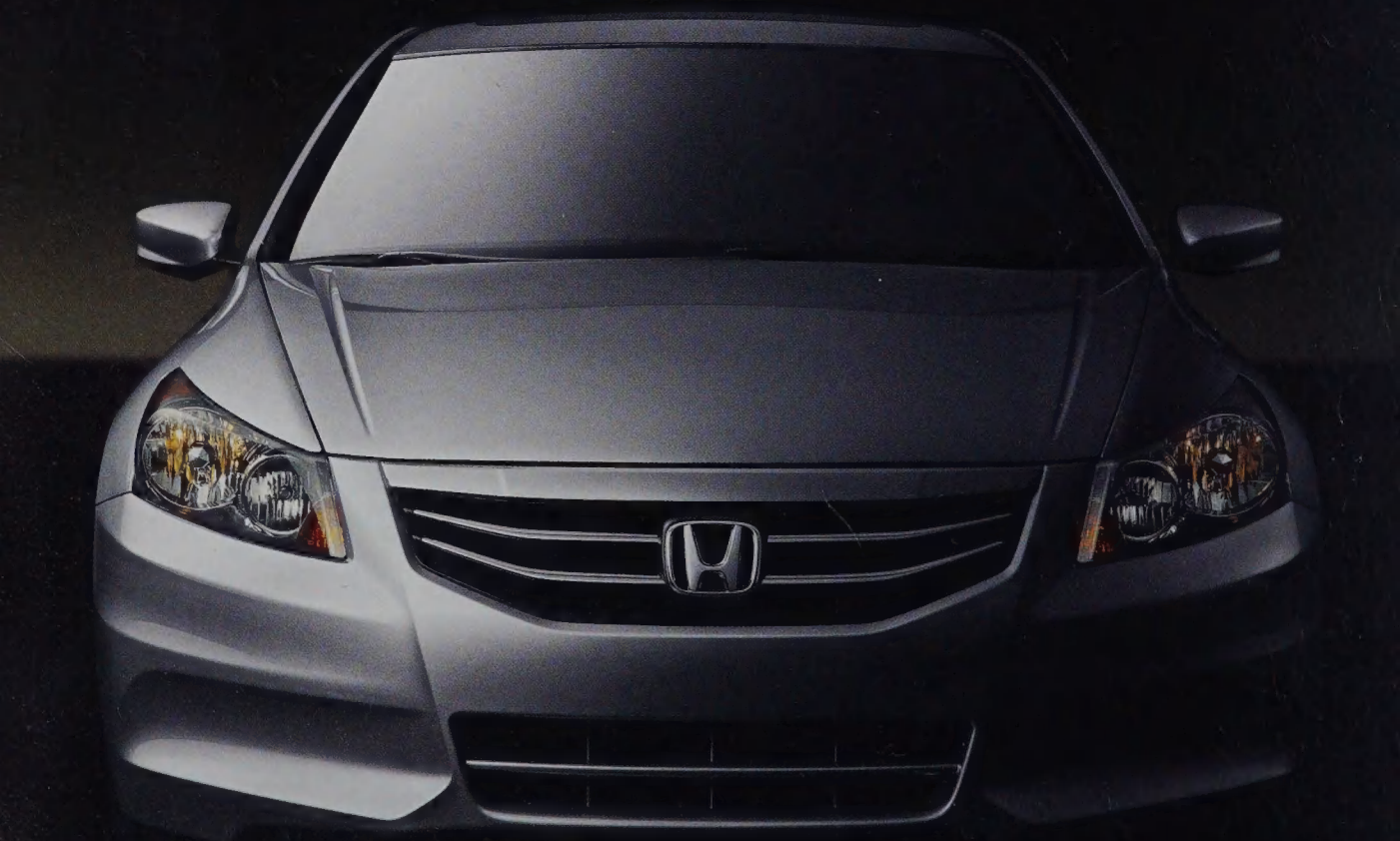

accord.honda.com 1-800-33-Honda †Honda Accord received the lowest number of problems per 100 vehicles among midsize cars in the proprietary J.D. Power and Associates 2011 Initial Quality Study.℠ Study based on responses from 73,790 new-vehicle owners, measuring 234 models and measures opinions after 90 days of ownership. Proprietary study results are based on experiences and perceptions of owners surveyed in February – May 2011. Your experiences may vary. Visit jdpower.com. *23 city/34 hwy/27 combined 2012 EPA mileage estimates for Accord 4-cylinder Sedan models. Use for comparison purposes only. Actual mileage will vary. ©2011 American Honda Motor Co., Inc.

VOL. 222 • NO. 1

# NATIONAL GEOGRAPHIC

*Are they beings that have come up from deep within the Earth?*
page 104

LYNN JOHNSON

No more than a thousand people speak the Seri language in Mexico. Marcela Díaz Félix is one of them. Here she uses a scarf for shade as she visits her father's grave.

## *July 2012*


**30 The Riddle of Easter Island**
How did the statues move? That question puzzles archaeologists—and modern-day islanders.
*By Hannah Bloch Photographs by Randy Olson*

**50 Epic Storms**
Is that a spaceship? Or a mushroom cloud? Or a strange skyscape whipped up by wild weather?
*By Jeremy Berlin Photographs by Mitch Dobrowner*

**60 Vanishing Voices**
A language goes silent every 14 days. That could mean the end for words like *tradzy, azaac, khei-àt.*
*By Russ Rymer Photographs by Lynn Johnson*

**94 Life in an Icy Inferno**
The breakfast of scientists freezes in the bowl. But weird microbes, possibly from Earth's bowels, thrive in the hot soil of an Antarctic volcano.
*By Olivia Judson Photographs by Carsten Peter*

**116 Russian Summer**
In vacation cottages the women are in housedresses. The men, Speedos and rubber boots. They brood, plant, party, and restore their souls.
*By Cathy Newman Photographs by Jonas Bendiksen*

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**Sabertooth Vegetarian** ▸
A fossil unveils a bizarre creature whose huge teeth chewed leaves.

**Stumble Stones**
Bearing the names of Hitler's victims, they're installed on Europe's sidewalks.

**Mental Mapping**
The map in your head likely faces north.

**Plastic Cash**
Canada introduces polymer bills. They cost more to make but last a lot longer.

**Cricket Chirps** ▸
They're linked to the temperature.

**Vertical Greenery**
How do urban gardens grow? In many cities the answer is: up the wall.

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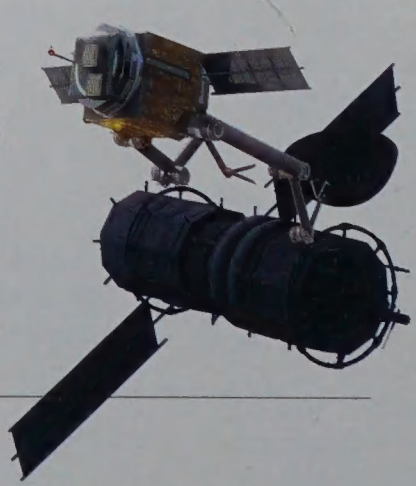
**Fill 'er Up…in Space** ▸
Mission: figure out a way to refuel and repair old satellites.



**Handwriting on the Wall**
Nowadays students rarely use cursive.

**Forest Migration**
Seedlings head north to see how global warming will affect the range of trees.

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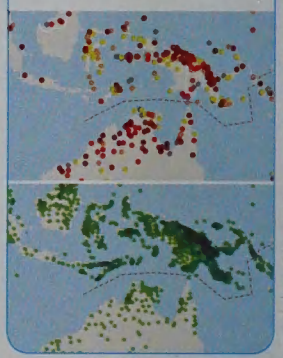
EXCLUSIVE ON THE IPAD

**Easter Island**
Video
*An animated statue tries different ways of "walking."*

**Vanishing Languages**
Interactive Map
*Find out where native tongues are in danger.*



TOP: HANS WEISE, NGM STAFF; MAP: VIRGINIA W. MASON, NGM STAFF

**On the Cover**
The illustration is based on a new theory about how ancient Easter Islanders used ropes to "walk" the statues.
*Art by Fernando G. Baptista, NGM Staff*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**Blue Bird of Paradise** *(Paradisaea rudolphi)*
**Size:** Head and body length, approx. 30 cm (12 inches) **Weight:** 124 - 189 g (4.4 - 6.7 oz) **Habitat:** Prefers lower montane forest; requires primary forest to display **Surviving number:** Estimated at 2,500 - 10,000

*Photographed by Tim Laman*

# WILDLIFE AS CANON SEES IT

The ultimate show-off? Displays don't get much more spectacular than that of the blue bird of paradise. Hanging upside down, the male spreads his flank feathers into a triangular fan, raises and lowers his long tail plumes and catches the light in such a way that he shimmers in blue and violet. Accompanying vocalizations include cawing and a rhythmic buzzing sound. The female, nearly as colorful as her mate, is on her own when it comes to incubating her eggs and caring for her young. The world those young inherit is on the verge of becoming paradise lost, threatened by habitat loss due to agriculture, logging and mining.

As we see it, we can help make the world a better place. Raising awareness of endangered species is just one of the ways we at Canon are taking action—for the good of the planet we call home. Visit **canon.com/environment** to learn more.

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# The Power of Voice

Lynn Johnson's voice is calm, thoughtful, and quiet—but not too quiet. She pulls you in. You want to catch every word. Her images also pull you in and compel you to catch every nuance. They are insightful, intelligent, and above all, profoundly human.

We knew we wanted Lynn to photograph this month's story "Vanishing Voices." We also knew it wouldn't be easy. How, after all, do you visualize a story about the spoken word? Native tongues are imperiled. Linguists estimate that nearly half the world's languages will disappear by the next century. Lynn's challenge was to show what is usually just heard.

**Photography, Lynn says, is not unlike meditation.**

Lynn Johnson has shot 21 feature stories for the *Geographic* since her first in 1989.

She did not disappoint. Not only that, but she made it look effortless. How does she do it?

Photography, she says, is not unlike meditation. "It's a mind always at the ready. You go in knowing your story, then you are respectful of what and who is present."

The last sentence is the key to her success. The people she meets quickly sense her respect for them and trust her. The proof is in the photographs she makes. The intimacy she captures can come only from a relationship grounded in trust.

How do you get there?

"By being yourself," she says. "The more authentic you are, the more authentic you can be with others. It has to come from an intention not to manipulate."

Look closely at her images. They illuminate and glow with tenderness. Most of all, they magically give a voice to those in danger of losing theirs.

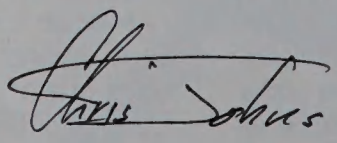



PHOTO: ANNIE O'NEILL

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# The Apostles

Andrew Todhunter's article states: "Adhering to a faith that challenges the Hindu caste system can still be risky." This grossly distorts India's exemplary record as a diverse, secular society. For a nation that is 80 percent Hindu, India has had Muslim and Sikh presidents, a Sikh prime minister, and many Christians, Zoroastrians, and others in key positions. Its most influential political figure, Sonia Gandhi, was born in Italy and is a Roman Catholic. Churches, mosques, gurdwaras, and temples can be seen across India. To convey the truth, context is important, and I wish the article had provided it.

**SUDHIR KRISHNA**
**Sunnyvale, California**

I am a 62-year-old South Buffalo, New York, Irish Catholic. I was taught by Mercy nuns, Franciscan priests, and Jesuit professors. I thought I knew my faith until I read about Anil Kuldeep. This 19-year-old is pictured in a refugee camp in Odisha, India. Scars are visible from an eight-hour beating he received in 2008 at the hands of extremist Hindus for refusing to give up his Christian faith. I think this was the type of faith that all those nuns, priests, and professors tried to pound into our heads all those years ago. Your picture of young Anil was worth 10,000 lectures. I hope his faith and your picture will lead to a better life for him. I am humble and a little bit jealous.

**BRIAN M. STANTON**
**Orchard Park, New York**

What leaps out of Todhunter's scholarly article is the fervent faith that so many have in a very amorphous system of beliefs. The Egyptians held their sun god beliefs for thousands of years, and they were certainly an intelligent civilization. But they were wrong. The stories of a young holy man who impressed a small tribe of Jews with the power of love must be reexamined for his example to endure.

**IVAN LADIZINSKY**
**Delray Beach, Florida**

I hail from Cape Comorin (or Kanniyakumari) on the tip of India. We believe a slightly different history than what I read. We believe Thomas the Apostle built seven and a half churches. From Thiruvithancode he came to our town; there he built a small shrine, which is a better word to use than church. While he was building, the Brahmans drove him out, and he fled to Madras. He could not finish, and that is why we call it a half church.

**HERMANAGILD JAYACHANDRA**
**Boulder, Colorado**

The Bible is capable of speaking for itself, and we would all be the better if we let it do so.

**JUDY McFARLAND**
**Nashville, Tennessee**

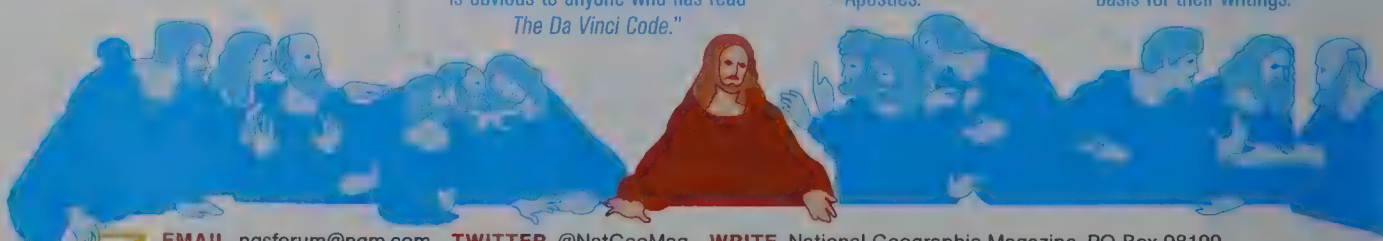
**FEEDBACK** *Many readers' responses focused on individual Apostles.*

"No Apostle was chastised more for his many doubts throughout the Gospels than **Peter.**"

"Interesting that the cover avoids showing the person seated to Christ's right. The reason for this is obvious to anyone who has read *The Da Vinci Code.*"

"Sounds to me like **Thomas's** doubt was shared by all the Apostles."

"Mark wrote first, and **Matthew** and Luke used most of his material as a basis for their writings."



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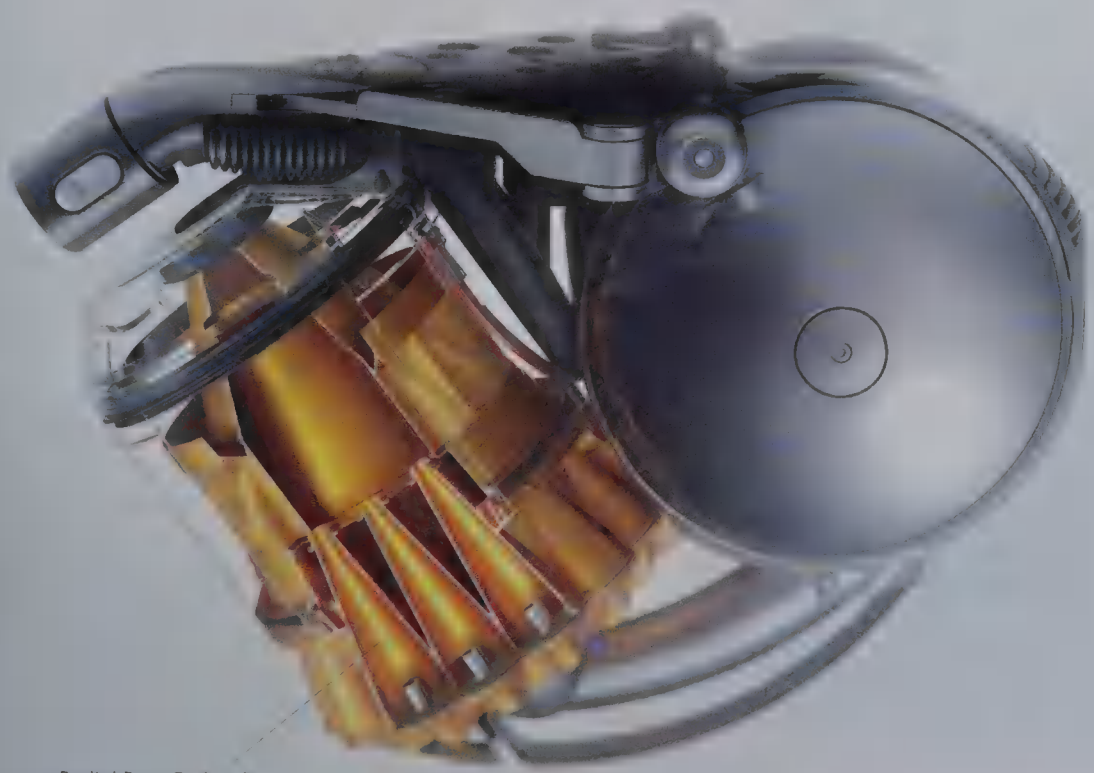
GRAPHIC: JASON TREAT, NGM STAFF



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## Erratics

I live at the bottom of ancient Glacial Lake Missoula, and until the recent issue arrived I thought I was the only one who loved erratics. I have painted about 30 portraits of these gentle giants resting in a mule pasture north of town. They take on a wonderful and mysterious presence in the first snow of winter. Our erratics were said to have arrived on ice rafts, then tumbled down to the bottom of the lake.

**R. WADE NELSON**
**Thompson Falls, Montana**

Interesting to read that glaciers formed during the most recent ice age started melting around 21,000 years ago. We must be naive to think we can stop them from melting.

**JOE LANDINO**
**Columbia, North Carolina**

**When is the world going to play hardball with the butchers involved in the rhino horn trade?**

## Rhino Horn Trade

For anybody who has looked on the unmitigated failure of a legal trade in ivory to reduce elephant poaching, the prospect of permitting a similar trade in rhino horn can only inspire a sense of déjà vu. Rhinos teetered on the brink of extinction once in the past 30 years, but the current crisis has an added dimension—the involvement of organized international criminal syndicates in countries that are neither range states nor major consumer markets, syndicates speculating on the demise of the rhino by stockpiling horn.

**MARY RICE**
**Executive Director**
**Environmental Investigation Agency**
**London, England**

Poaching is a disgusting and cruel practice, especially when what is being taken from the animals offers a hypothetical cure for hangover and fever.

**MIRA PAUL**
**Pine, Colorado**

When is the world going to play hardball with the butchers involved in the rhino horn trade? Solution number one: Put out a bulletin announcing that toxic rhino horns have been sold into the black market. Why would you buy a product that would make you violently ill? Solution number two: Develop a counterfeit rhino horn and saturate the market, making the stocks worthless.

**BILL CODY**
**Camillus, New York**

## Marseille

As an ancient historian, I would like to make a correction about the city's past. Marseille was not founded by the Phoenicians but rather by their enemies the Greeks. The misinformation is due to the similar name of the Greek city-state of Phocaea that founded Marseille. In the sixth century B.C. the Phocaeans established the colony of Alalia in Corsica. Carthage, a Phoenician city-state, felt threatened and considered this an intrusion. A combined fleet of Etruscans and Carthaginians attacked Alalia. A great sea battle ensued that ended in a draw. However, the Phocaeans suffered serious losses and withdrew to the south of France, where they founded Massilia (modern-day Marseille).

**NICK ALEXANDER**
**Oak Park, Illinois**

*Many Marseillais, and others, believe the city was founded by Phoenicians, based on indications that they may have spent time in the area in the eighth and seventh centuries B.C. But we missed the opportunity to clarify that the current city was actually founded by Greek Phocaeans from Asia Minor in 600 B.C.*

## NEXT: Monument

Just who has the bigger obelisk, partner? You state the Washington Monument is the world's tallest freestanding stone structure. You shame Texas one-upmanship because, as any Lone Star type person knows, the San Jacinto Monument, located on the pristine Houston Ship Channel near the Bayou City, is faced with stone, has no external support, and is two good Texans taller (nearly 12 feet) than the Washington Monument.

**ROBERT TAYLOR**
**Houston, Texas**

*While taller at roughly 570 feet, the San Jacinto Memorial Monument is not a freestanding stone structure: It has a poured concrete center faced in stone.*

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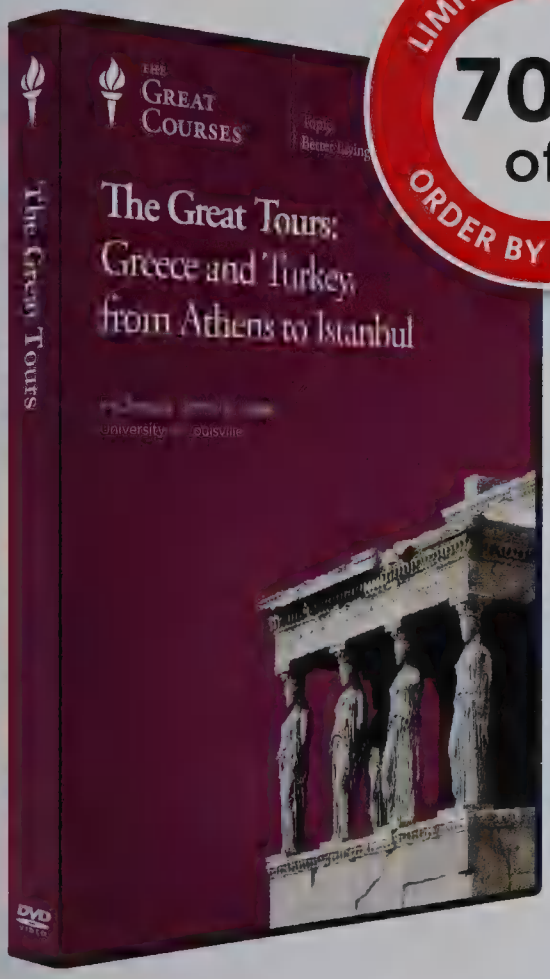


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Santa Fe, New Mexico–based photographer Ralph Lee Hopkins travels to the world's wild places with Lindblad Expeditions and National Geographic

# RALPH LEE HOPKINS

# MY VIEW

## Being in the Moment in Grand Canyon National Park

It was a family camping trip that first introduced me to our national parks, with the Grand Canyon having the biggest impact on me. Growing up on the East Coast I had never seen anything like it—a canyon so deep that I couldn't see the bottom. It was this childhood memory that inspired me to move west. A twist of fate landed me at Northern Arizona University, where I studied the rim rocks of the Grand Canyon for my master's degree.

Matkatamiba Canyon is one of the hidden gems and is particularly photogenic in the late afternoon when reflected light from the canyon walls illuminates the sinuous layers in the Muav Limestone. What I love most about photographing in our national parks, and the Grand Canyon in particular, is the sense of freedom and being in the moment that keeps bringing me back year after year.

This is Ralph Lee's view.
Find your own perfect national parks view at *NatureValleyTrailView.com*.

Photo: Ralph Lee Hopkins' family, Matkatamiba Canyon, Grand Canyon National Park

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# VISIONS

**United States**
July means frolicking with goggles in a spray of firefighting foam in Lehi, Utah. The tradition, now in its fourth year, takes place this month to celebrate Pioneer Day, a state holiday honoring the 1847 arrival of Mormons in the Salt Lake Valley.

PHOTO: LANCE BOOTH, *DAILY HERALD*

**United States**
Though more than a century old, these bird eggs retain a fresh palette at the University of Nebraska State Museum. The specimens, whose contents were emptied via shell holes, include a sandhill crane from Nebraska (far right) and five blue-winged thrush eggs (far left).

Order prints of National Geographic photos online at Prints.NGS.com

**United Kingdom**
On a snow-carpeted field in Essex County's Weald Country Park, a young fallow deer pauses to groom while foraging. Known as a pricket at this stage, he sports his first set of antlers—simple spikes of hard bone.

PHOTO, NICK ANSELL, PRESS ASSOCIATION/AP IMAGES

This page features two photographs: one chosen by our editors and one chosen by our readers via online voting. For more information, go to *ngm.com/yourshot*.

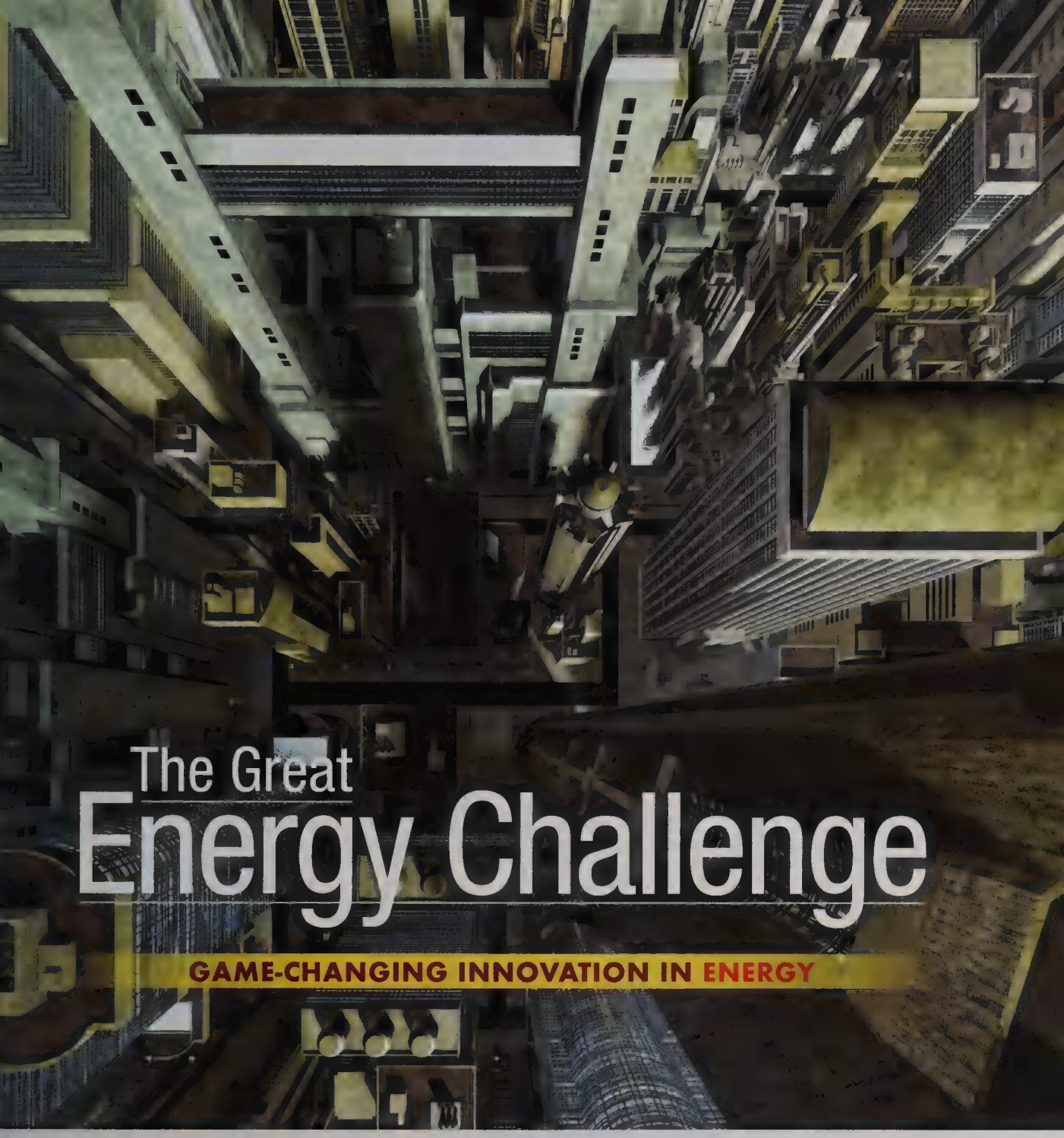
EDITORS' CHOICE **Liz Andersen** Fredrikstad, Norway

As a child in the sixties, Andersen dreamed of being a fashion designer. "These Barbie dolls were my guinea pigs—I made clothes for them," she says. Today she's a post office manager, and her friends' kids enjoy playing with the dolls, dressed here in vintage clothing for a beach excursion.

READERS' CHOICE

**Nathan Goshgarian**
Boston, Massachusetts

While completing his master's degree in conservation biology in New Zealand, Goshgarian, 32, and a friend explored South Island in a camper van. At Milford Sound, "one of the most breathtaking places on Earth," he waited several hours for winds calm enough to shoot.



# The Great Energy Challenge

## GAME-CHANGING INNOVATION IN ENERGY

**The future of energy** is an issue that touches every person on the planet. What are the **breakthroughs** and **new technologies** that will enter the energy mix? How will we drive change for **smarter mobility?** As we move to a population of nine billion by mid-century, how do we manage the **stress on the intersection of food, water, and energy?** Do rapidly **growing cities** offer a blueprint for energy efficiency?

To help address these questions and more, National Geographic, in partnership with Shell, launched **The Great Energy Challenge.** The site includes **news, quizzes, interactives, blogs, videos, photo galleries, and features about projects** supported by the Great Energy Challenge and its distinguished advisors. It's a one-stop resource where you can participate and be heard, and find authoritative briefings on game-changing innovations in energy worldwide. Get started now at **GreatEnergyChallenge.com.**

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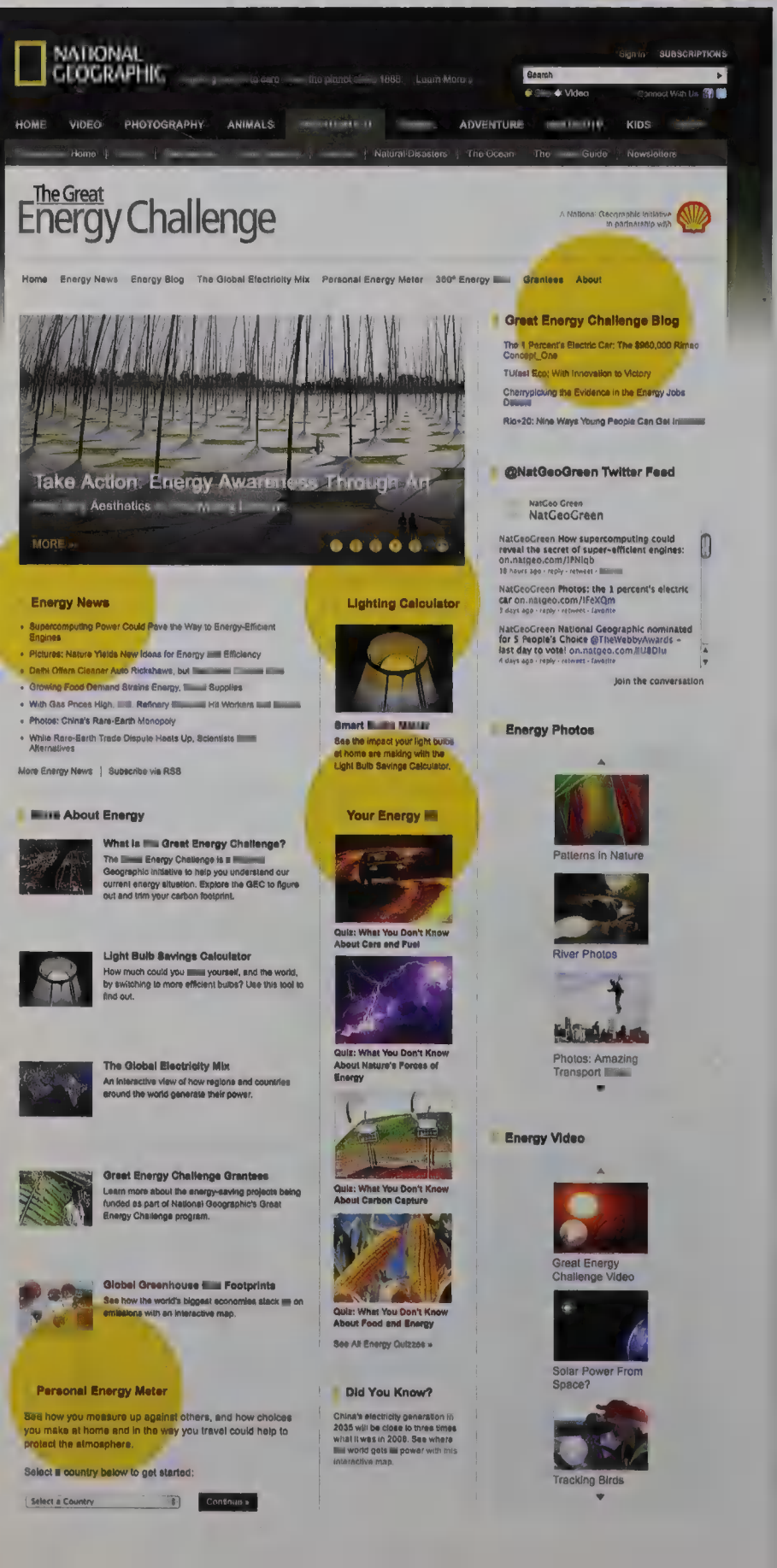
# The Great Energy Challenge




## TECHNOLOGY AND INNOVATION: REPORTING FROM AROUND THE WORLD

Written by experts and constantly updated, **Energy News** takes you around the world in pursuit of news about resources, renewables, and breakthrough practices. You'll read about global innovations–such as solar powered irrigation that brings food, water, and light to African villages–that reflect the breadth of the current energy situation. **The Energy Blog** offers analysis, personal stories, and actionable information from scientists, think-tank leaders, and National Geographic editors and explorers.

## SMARTER MOBILITY: PHOTO GALLERIES AND GLOBAL NEWS

As the economic situation improves for developing nations, so does the demand for cars–which accelerates the need for fuel. **Energy News** and **The Energy Blog** showcase super-computer simulations that will contribute to super-efficient combustion for car engines, reveal San Francisco's award-winning parking reform program, and even offer a sneak peek at the future: flying cars.

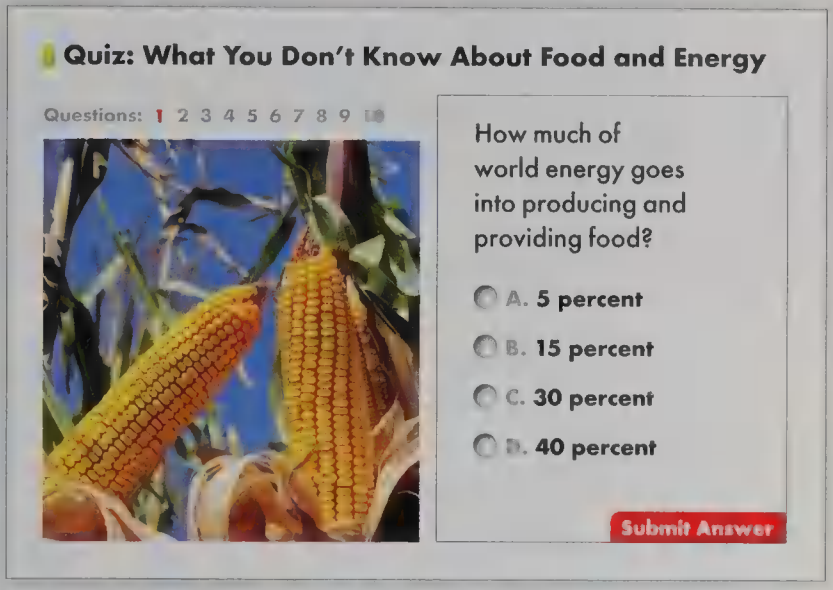
**Photo Galleries** provide a rich testimony to transportation innovation. From Bogota to Zurich, Fez to Tokyo, tour "Twelve Car-Free City Zones" that reduce carbon emissions and restore leisurely strolling. Check out "Nature Yields New Ideas for Energy and Efficiency," on how engineers draw inspiration from schools of fish, termite mounds, and the photosynthesis of leaves. Then ramp up on "The Road to 55 MPG," a look at the auto industry's efforts to improve fuel efficiency.

Go to **GREATENERGYCHALLENGE.COM**
to learn more about and contribute to the world's energy solutions.

## TEST YOUR ENERGY KNOWLEDGE

Featuring amazing facts and energy-saving tips, **Energy Quizzes** cover subjects that affect us all, such as Food, Cars, Biofuels, and Cities. You find out which nation leads in ethanol production, how drivers can reduce fuel use, how cities like Seoul keep warm through urban planning, and the symbiotic relationship between energy and water.

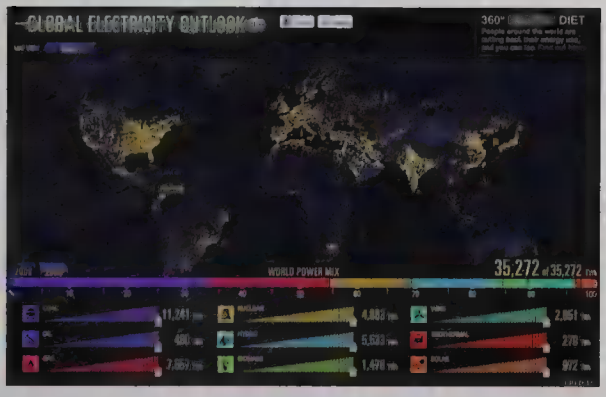
Try your hand at this sample question from the **Food and Energy quiz** to get started.

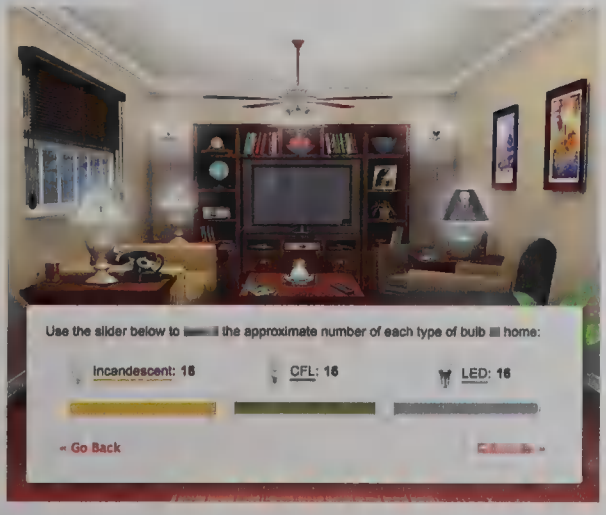

Quiz: What You Don't Know About Food and Energy
Questions: 1 2 3 4 5 6 7 8 9 10
How much of world energy goes into producing and providing food?
A. 5 percent
B. 15 percent
C. 30 percent
D. 40 percent
Submit Answer

ANSWER: C. According to the Food and Agriculture Organization of the United Nations, the food sector accounts for 30 percent of all global energy consumption and 22 percent of total greenhouse gas emissions.

## CALCULATE YOUR ENERGY USE WITH INTERACTIVE FEATURES

**The Great Energy Challenge** provides consumers with an interactive way to measure and trim their carbon footprints with the **Personal Energy Meter,** and to see what fuels the world's electricity output with the **Global Electricity Mix.** The **Light Bulb Savings Calculator** brings it all home: simply input the number and type of bulbs you use in your home to see how you can save energy—and how you compare with the average U.S. household.





Use the slider below to [redacted] the approximate number of each type of bulb [redacted] home:
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THE GREAT ENERGY CHALLENGE
## GRANTEE SPOTLIGHT
## ECOLEÑA GUATEMALA

*(from left to right clockwise)*
*Photo One: Teresa Imul Us–The future of EcoLeña.*
*Photo Two: EcoLeña producers learning about a bio-diesel powered molina/grinder.*
*Photo Three: Sacapulas EcoLeña producers preparing materials.*

*Photographs by Joyce Stanley*

**The Legacy Project** provides training, technology, and media services for biomass fuel briquette production, environmental conservation, and income generation throughout the world. With the support of the Great Energy Challenge, the group is combating deforestation in Guatemala by helping to substitute fuel wood and charcoal with hollow-core biomass briquettes (EcoLeña Guatemala). The project will establish a self-sustaining, income-generating network of briquette producers, trainers, and equipment suppliers in Guatemala.

Because of their technical simplicity and economic viability, fuel briquettes may outcompete the existing fuel wood supply, which directly or indirectly accounts for more than half of Guatemala's deforestation. The Legacy Foundation's important work will help ensure cleaner air within homes, improve the economic situation of participants, and protect forests in Guatemala and 45 other countries on our shared planet.

## A MESSAGE FROM SHELL
**Peter Voser, CEO, Royal Dutch Shell**

"Energy is vital to our daily life. As the engine of our economy and growth, it powers our homes, factories, and cities and provides millions of people with jobs. As the global population rises, more people are moving out of poverty and gaining access to energy. All sources will be needed to meet growing needs in a sustainable way. Everyone has a part to play."

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## A PANEL OF ADVISORS HELPS GUIDE THE GREAT ENERGY CHALLENGE

**by identifying and providing support for projects that focus on innovative energy solutions. The aim is to highlight local projects that have potential to expand to regional or global scale.**

**THOMAS E. LOVEJOY,** Advisory Team Chair, is a conservation fellow at the National Geographic Society and chairman of the Energy Advisory Committee. He is known for his work on biodiversity, and his innovations include the concept of debt-for-nature swaps and the public television series *Nature*.

**SALLY M. BENSON,** a leading expert in low-carbon energy supply, directs the Global Climate and Energy Project at Stanford University. She is a research professor in the Department of Energy Resources Engineering in the School of Earth Sciences.

**JOSÉ GOLDEMBERG,** the former environment minister in Brazil, helped guide that country's effort to replace much of its oil consumption with sugarcane ethanol. He is a professor at the University of São Paulo.

**DANIEL KAMMEN** is the Class of 1935 Distinguished Professor of Energy and the founding director of the Renewable and Appropriate Energy Laboratory at the University of California, Berkeley. He is a Contributing Lead Author for the IPCC and in 2010-11 was the Inaugural Chief Technical Specialist for Renewable Energy and Energy Efficiency for the World Bank Group.

**AMORY LOVINS** cofounded and chairs Rocky Mountain Institute–an independent, entrepreneurial, nonprofit "think-and-do tank" that drives the efficient and restorative use of resources.

**RAJENDRA K. PACHAURI** chairs the Nobel Prize–winning Intergovernmental Panel on Climate Change. He is director-general of the Energy and Resources Institute (TERI), renowned for its work in energy, the environment, forestry, biotechnology, and conservation.

# NOW

SKYCAST

*Overhead this month in parts of the world*

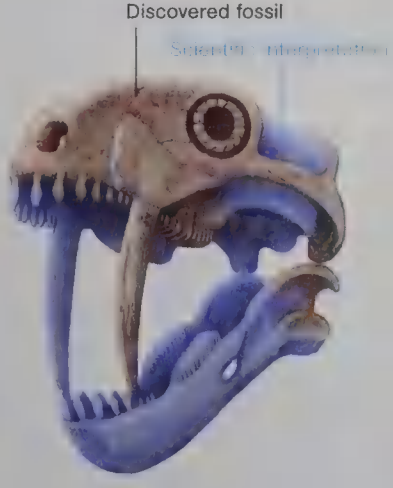
*July 28-29*
**Delta Aquarid meteor shower**

*This short-snouted, boar-size creature lived roughly 265 million years ago in what is now Brazil.*

## Sabertooth Vegetarian

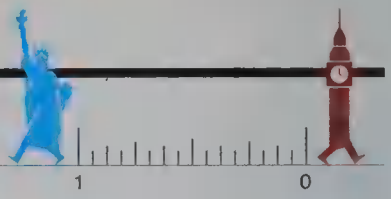
My, what big teeth it had—the better to eat plants with. That's what Juan Carlos Cisneros of Brazil's Federal University of Piauí concluded last year after studying the partial skull and worn dentition of a fossil species "so bizarre it was like finding a unicorn." Called *Tiarajudens eccentricus*, this therapsid—an extinct reptilian ancestor of mammals—efficiently chewed leaves and stems with interlocking horselike incisors and cowlike molars. Saber canines, like those of a modern musk deer, may have warded off predators and competitors.

Jörg Fröbisch of Berlin's Natural History Museum says the mishmash mouth offers evolutionary insights into the late Paleozoic, when herbivores became ascendant. Cisneros is now analyzing the rest of the remains, to get more than a mouthful. *—Jeremy Berlin*




ART: MAURICIO ANTÓN. SOURCE: JUAN CARLOS CISNEROS

New York City drifts about one inch farther from London every year.



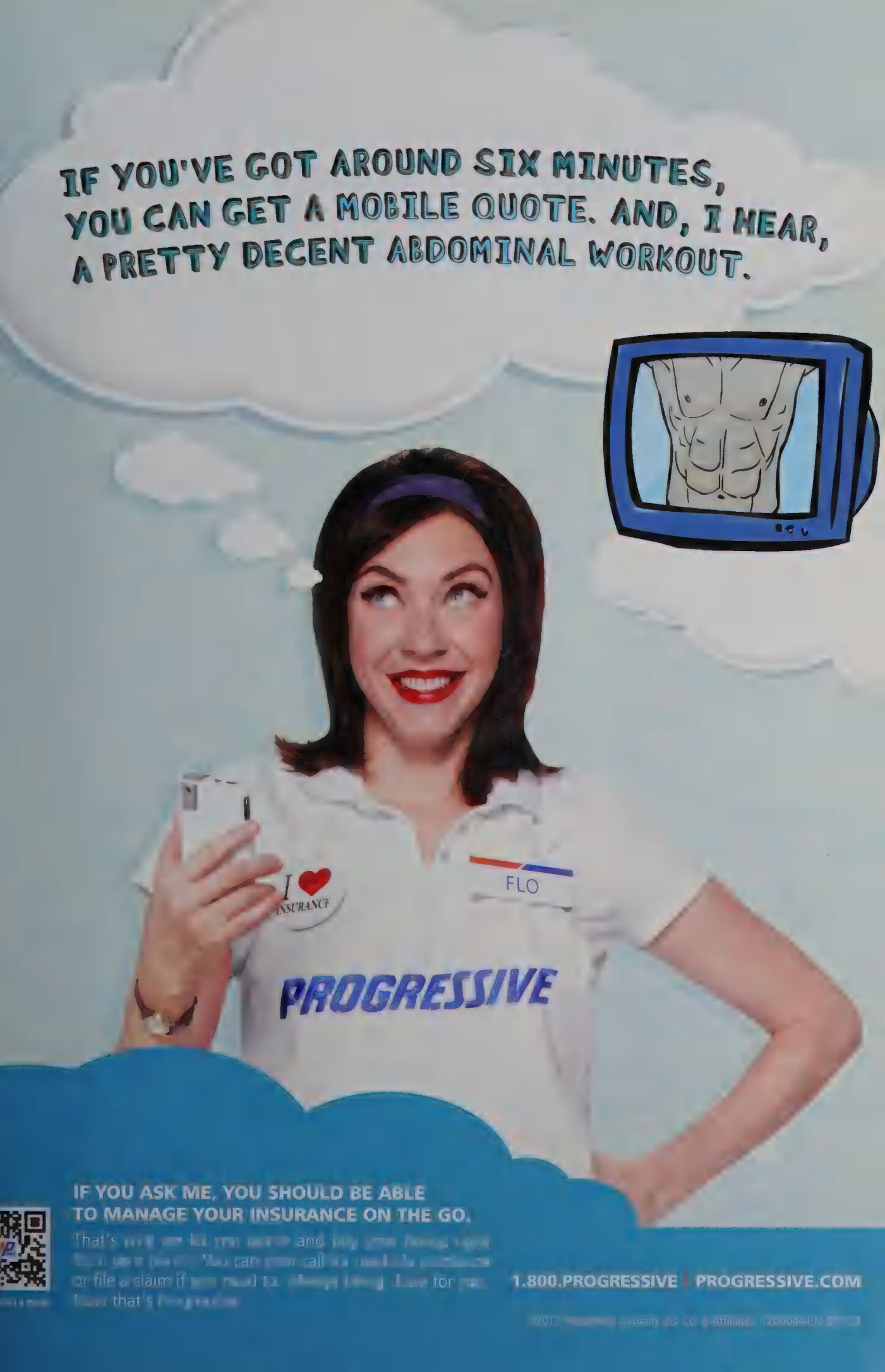
*Hand-engraved cobbles, here in Berlin, bring the names of Nazi victims "back to the houses where they lived," says the artist who installs them.*

**Stumble Stones** Sidewalks in Germany and nine other European nations are getting a historical makeover. Some 34,000 brass-capped cobbles bearing the names and fates of Nazi victims have been installed outside buildings where they lived or worked. German artist Gunter Demnig devised the idea; individual donors pay for the mini-memorials. Most of the names are Jewish, but Demnig has dedicated stones to Jehovah's Witnesses, political prisoners, and others. He calls them "stumble stones," hoping pedestrians will "stumble with their head and heart." Some municipalities stumble over the concept, arguing there are plenty of memorials and, besides, such reminders shouldn't be underfoot. Supporters appear to outweigh critics; Demnig continues to install the stones. *—Andrew Curry*

**WHICH WAY TO...?** It's a common question. A visitor asks where such and such is, and the local pauses, thinks, points. Familiar sites may seem to be the reference base for giving a person directions, but a new study suggests orientation plays a key role.

In Tübingen, Germany, researchers used a virtual model of the town to test the spatial knowledge of its residents. When asked to locate a place outside their line of vision, participants fared best if facing north. Their "mental maps," says psychologist Julia Frankenstein, seemed to mirror the layout of actual city maps and weren't rooted entirely in navigational memory. Not yet tested is her theory that the brain has a map of emotional landmarks too—like the site of someone's wedding. *—Catherine Zuckerman*

PHOTO: TIMOTHY FADEK. TOP GRAPHIC: ÁLVARO VALIÑO. SOURCE: USGS. LEFT GRAPHIC: OLIVER MUNDAY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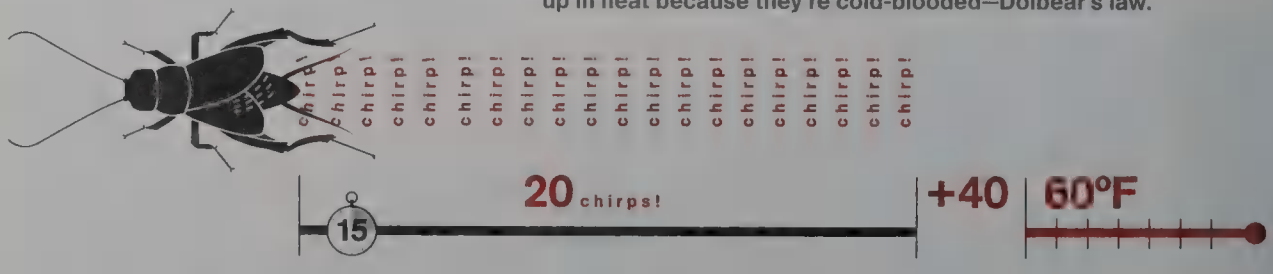
# Paying With Plastic

No longer is it cash *or* plastic in Canada. By late next year all freshly printed bills will be slick polymer notes packed with anticounterfeiting features. New $100 and $50 bills have already entered the currency stream, following a five-year design process and a bevy of wear-and-tear tests. Though more costly to produce, the plastic notes last at least 2.5 times as long as paper ones.

Security innovations include a wide see-through stripe with color-shifting holograms (right) and a maple leaf with numbers visible only under certain lighting. Security was the redesign's main driver, says Bank of Canada's currency chief, Gerry Gaetz. Counterfeiting cost Canadians nearly $13 million at its peak, in 2004. The country joins a handful of others in converting fully to polymer banknotes, pioneered by Australia in 1988. *—Luna Shyr*

## Is It Hot? Ask a Cricket.

**In 1897 physicist Amos Dolbear posited a link between temperature and how often crickets chirp, which speeds up in heat because they're cold-blooded—Dolbear's law.**




A simplified version of Dolbear's equation: Count the number of times a field cricket chirps in 15 seconds.

*Dolbear likely studied snowy tree crickets, but most field crickets work for rough estimations.*

Add 40 to the chirp total to arrive at the approximate temperature in degrees Fahrenheit.

PHOTO: MARK THIESSEN, NGM STAFF. GRAPHIC: ÁLVARO VALIÑO

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# Vertical Gardens

From Paris to Bangkok, Sydney to Seoul, green is growing up. Over the past decade, lush living walls—like this one next to a Madrid cultural center—have been planted wherever space is scant, beauty is absent, or air quality is poor.

French botanist Patrick Blanc's soil-free, auto-irrigated model (below) has been a blueprint for many public and private projects. But variety is in bloom. U.K. firm Biotecture builds modular systems with water-saving mineral wool, not felt. Walls by U.S.-based Green Living Technologies yield leafy greens and crops like carrots. And compost is at the root of many DIY setups.

Thousands of plants can grow vertically—making green walls a natural city solution in a crowded 21st century. —*Jeremy Berlin*

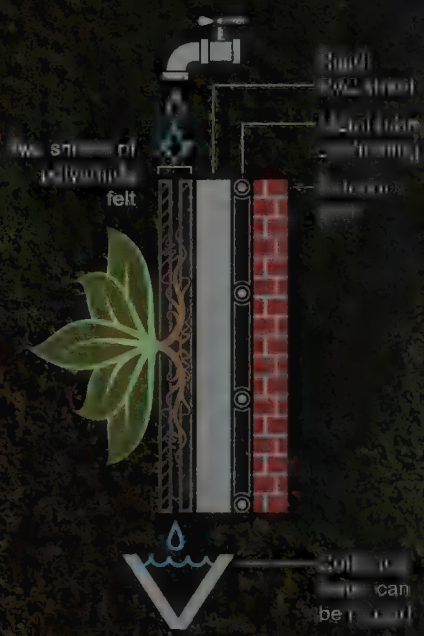


PHOTO: MARCO CRISTOFORI, ROBERT HARDING WORLD IMAGERY/GETTY IMAGES
GRAPHIC: JASON TREAT, NGM STAFF. SOURCE: PATRICK BLANC

NATIONAL GEOGRAPHIC

# *Inspire* Future Generations

Grace Cleere included National Geographic in her estate plans.

A communications expert for the government, Grace Cleere recently named National Geographic as a beneficiary in her will. "I included a bequest intention to National Geographic because I believe in everything the organization represents," says Cleere. "If we don't understand our world, we are bound to mistreat it. And if we are not curious about all living things on our planet, we are bound to lose them through thoughtlessness and indifference. National Geographic shines a spotlight on the critical issues of the day and proposes innovative solutions that are grounded in science. I feel good about my legacy knowing that National Geographic will leverage my gift so it can have the greatest impact."

It is easy to include National Geographic in your will. For more information about how to include National Geographic in your estate plans, or to let us know that you have already done so, please contact the Office of Estate Planning.

---

**TO MAKE YOUR BEQUEST**

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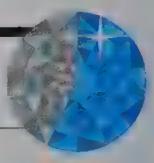
Photo: Adam Buchanan

57% of natural diamonds mined each year become jewelry. The other 54.6 million carats are used in industry.



**Wonder Wasp**

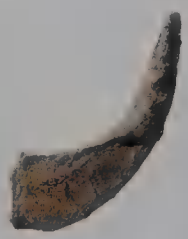
**A small number of species, including humans, primates, and some wasps, have a special skill for learning faces.**

# About Face

We know that paper wasps can deliver many mighty stings. Now research shows that one type, *Polistes fuscatus,* can also distinguish among wasps' faces, indicating it has brains in addition to brawn.

When charged with choosing between pictures of two different wasps, the insects identified the image linked to a reward 74 percent of the time, says biologist Michael Sheehan. When pictures of caterpillars—their prey—were swapped in, the success rate plummeted to 53 percent.

Sheehan tweaked the wasp photos (such as bottom row, center) and retested. This time the bugs flopped. The upshot? If facial features are intact, these social creatures can spot a face in the crowd. *—Catherine Zuckerman*



**ANCIENT ANGLERS** Deep-sea dinners have been on our menu since the Stone Age. That's what Sue O'Connor of the Australian National University learned when Timor-Leste's Jerimalai shelter—home to Pleistocene-epoch humans—yielded 42,000-year-old bones from tuna and other species. The site also surrendered the world's oldest fishhook (left). As many as 23,000 years ago, it was fashioned from a sharpened snail shell, likely strung with bait, and used to snare reef fish. O'Connor says the bones and hook show "that early modern humans had advanced maritime skills," helping them reach Australia some 50,000 years ago. *—Jeremy Berlin*

PHOTOS: MICHAEL SHEEHAN (WASPS); SUE O'CONNOR. GRAPHIC: ÁLVARO VALIÑO. SOURCE: USGS

*Actual size is 40.6 mm*
*Weight 31.101g*
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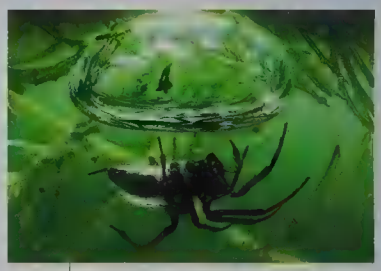
# Coffin Coiffures

In ancient Egypt styled tresses were complex expressions of identity. Male and female, young and old, noble and peasant chose among curls, waves, twists, braids, extensions, wigs, razor cuts, and dye jobs according to their position in society, religious canons, and personal preference. These indicators of style and status were equally important in the afterlife, and the hair of the dead was arranged with just as much care. A recent study of 18 mummies at the University of Manchester revealed that most had hair coated with a fatty substance—perhaps applied after mummification, like modern styling gel, to prepare a postmortem hairdo. Further testing promises to reveal the makeup of this mysterious product with permanent holding power. *—A. R. Williams*

*Lady Rai went to her grave with elaborate braids in the 16th century B.C. Half were unwrapped during research in 1909.*

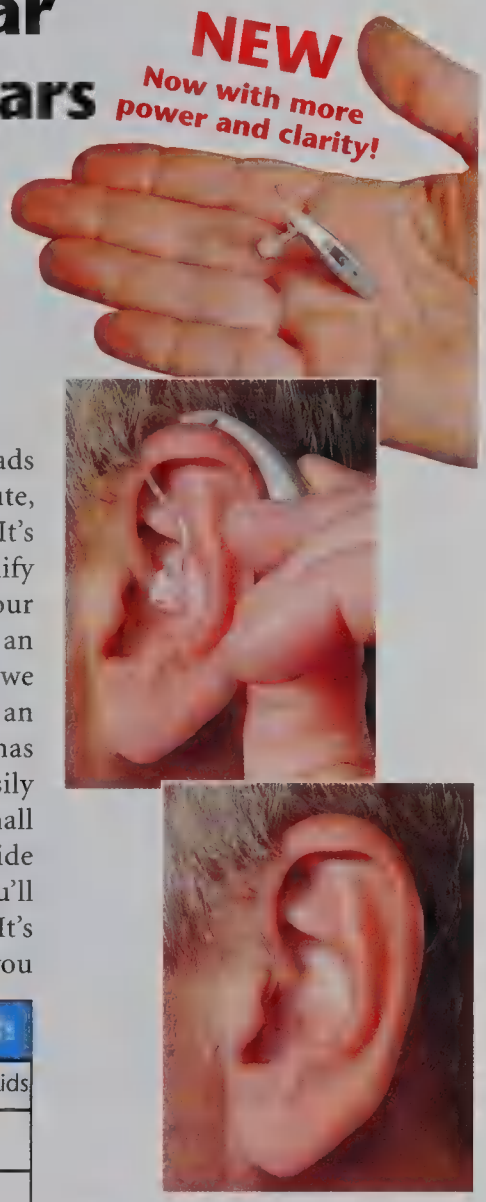


## The Diving Bell Spider

It looks like your average air bubble, but this glimmering globule (above) is held underwater by a silk web to sustain the life of the spider *Argyroneta aquatica*. New research from Berlin's Humboldt University shows the Eurasian species can live in resting mode for at least a day using oxygen that passes from the water into the bubble—similar to the way a gill works. Air connects with openings on the spider's body that take up vital oxygen. When the "diving bell" shrinks, the spider surfaces and replenishes it with fresh air. Babies even hatch underwater, inside the bell. So why live the life aquatic at all? The better to dine on small fish and other animals in slow-moving waters. *—Luna Shyr*

PHOTOS: UNIVERSITY OF CHICAGO LIBRARY ELECTRONIC OPEN STACKS (LEFT); PHOTOLIBRARY

# The invention of the year is great news for your ears




*Perfect Choice HD™ is easy to use, hard to see and costs far less than hearing aids... it's like reading glasses for your ears™!*

## New Personal Sound Amplification Product is an affordable alternative

Over the years, technology has made the way we live easier, safer and more convenient. In many cases, it's even made many products more affordable... (remember how much the first VCRs used to cost?). Unfortunately, the cost of hearing aids never seemed to come down. Now, a new alternative has been invented... it's called Perfect Choice HD™.

***"Reading glasses for your ears"***

Perfect Choice HD is NOT a hearing aid. Hearing aids can only be sold by an audiologist. In order to get a hearing aid, you had to go to the doctor's office for a battery of tests and numerous fitting appointments. Once they had you tested and fitted, you would have to pay as much as $5000 for the product. Now, thanks to the efforts of the doctor who leads a renowned hearing institute, there is Perfect Choice HD. It's designed to accurately amplify sounds and deliver them to your ear. Because we've developed an efficient production process, we can make a great product at an affordable price. The unit has been designed to have an easily accessible battery, but it is small and lightweight enough to hide behind your ear... only you'll know you have it on. It's comfortable and won't make you feel like you have something stuck in your ear. It provides high quality audio so sounds and conversations will be easier to hear and understand.

**Perfect Choice HD vs Traditional Hearing Aids**

| | Perfect Choice HD | Traditional Hearing Aids |
|---|---|---|
| Lightweight and Inconspicuous | YES | Some |
| Easy Toggle Switch Adjustment | YES | Few |
| Intelligent Setting Memory | YES | Few |
| Tests and Fittings Required | NO | Yes |
| Affordable | YES | as much as $5000 |
| **Friendly Return Policy** | **YES** | **Rarely** |





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80326

The kiwi is the same size as ■ chicken, but its eggs are six times as big—and equal to one-fifth its own weight.

*A white rump marked by patches of pigment, known as leopard spotting, is a hallmark of the Appaloosa horse breed.*

## Ancient Appaloosas

Cave artists aren't known for their precision—archaeologists have debated whether prehistoric paintings were mostly symbolic or accurate reflections of animals. The creatures that grace the walls of Pech Merle cave (left) in France date back to 23,000 B.C. Horses? Definitely; predomestic equines had been roaming Europe for millennia by then. But spotted horses? New research says yes. Though dappled coats were thought to exist only in a few modern breeds, the genotype showed up frequently in DNA analysis of horse bones from western Europe's Pleistocene epoch. This means early humans "made very correct observations of their environment," says study co-author Arne Ludwig of Berlin's Leibniz Institute for Zoo and Wildlife Research. In other words, those prehistoric artists were spot-on. *—Amanda Fiegl*

**ET CETERA**

University of Chicago research shows that **RATS HAVE EMPATHY** and value freeing trapped fellow rats on par with eating chocolate. • A South African excavation found a **77,000-YEAR-OLD LEAF MATTRESS**, likely used by multiple family members. • New evidence from NASA's WISE telescope may exonerate **ASTEROID FAMILY BAPTISTINA**, charged with killing off the dinosaurs 65 million years ago. • Biologists have identified **12 NEW FROG SPECIES**, plus rediscovered three not seen in 75 years, in western India.

PHOTOS: KEVIN PULLEN, APPALOOSA HORSE CLUB; PATRICK CABROL, CENTRE DE PRÉHISTOIRE DU PECH MERLE, CABRERETS, FRANCE (LEFT). GRAPHIC: ÁLVARO VALIÑO

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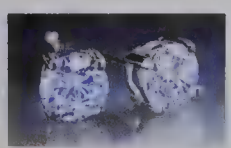

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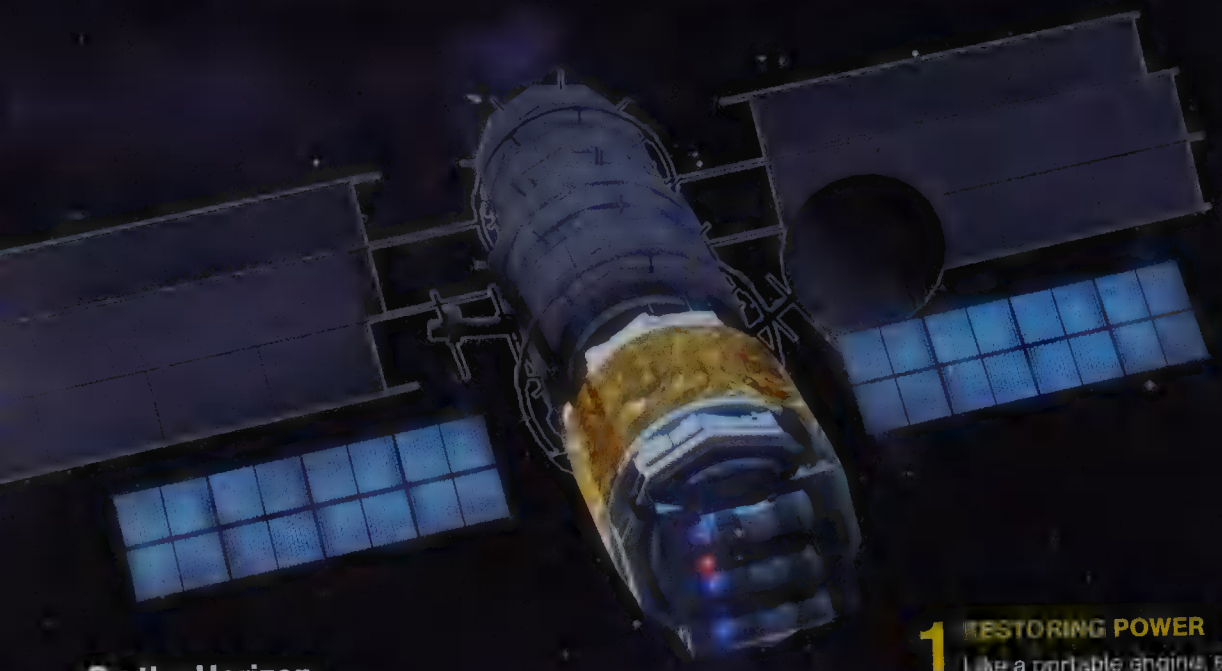
# NEXT

## Giving old satellites new life tackles costs and space clutter.



### On the Horizon

Here's a look at three of the most promising approaches to extending the utility of aging satellites.

**1 RESTORING POWER**

Like a portable engine, a "mission extension vehicle" attaches itself to an old satellite to provide a new source of propulsion. The fuel in such vehicles could propel a satellite for years.

**RECYCLING SATELLITES** | On board the International Space Station a robotic arm is demonstrating how aging satellites could become young again. In March "Dextre" began twisting and prodding mock equipment on NASA's Robotic Refueling Mission—an early step toward developing a vehicle with similar arms that could one day refuel and repair satellites in space.

Hundreds of satellites sit in geosynchronous orbit today. When their fuel runs low, they'll boost themselves above the traffic and become space junk. NASA's Benjamin Reed, who notes there's no way to service satellites now, envisions a vehicle that travels among working ones to provide fuel, basic repairs, or transport to another orbit. DARPA and private companies are working on vehicles of their own. Some would have to hack into fuel tanks and hardware that weren't meant to be accessed once launched. Such robotic repair technology could also aid in future manned space missions. Reed says the greatest challenge, though, is pulling up to and grasping a fast-moving satellite. "Every single satellite in space, when it runs out of fuel, is disposed of," he says. "We're trying to break that paradigm." —*Elizabeth Preston*

## 2 REFUELING

Many satellites go out of service simply because they run out of fuel and weren't designed to be refueled. A vehicle acting as a roving service station would cut into the satellite and remove safety caps to connect a fueling hose.

## 3 REUSING PARTS

DARPA is developing technology that would remove working antennas and other components from defunct satellites and attach them to new ones. The technique would lower the cost of producing and launching satellites.

## TARGET SATELLITES

Of the methods shown here, repowering and refueling could affect about 240 satellites currently in orbit. An additional 330 are suited to having their parts reused.

ART: STEFAN [illegible]
RESEARCH: [illegible]
[illegible]: BENJAMIN REED, NASA GODDARD
[illegible]: DAVID [illegible], DEFENSE ADVANCED RESEARCH [illegible]
[illegible]: DAN [illegible]

Food demand is expected to rise some 70 percent by 2050. To meet the need, the next green revolution is focused on helping small farmers.

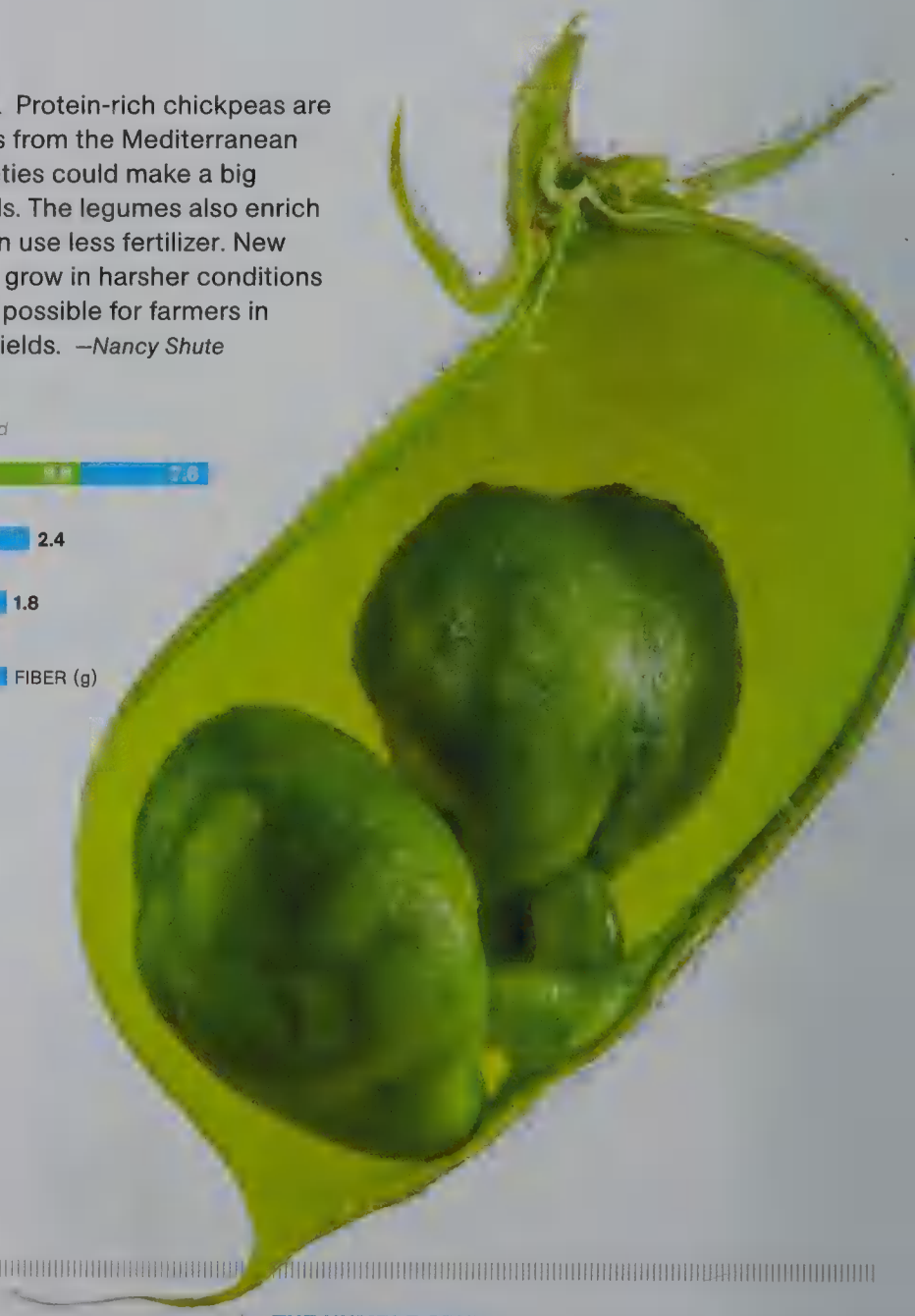
# Packing a Punch

Protein-rich chickpeas are grown in more than 50 countries from the Mediterranean to South Asia, so improved varieties could make a big contribution to future food needs. The legumes also enrich soil with nitrogen, so farmers can use less fertilizer. New chickpea varieties developed to grow in harsher conditions and fight off blight have made it possible for farmers in Africa and Asia to double their yields. *—Nancy Shute*

**Nutritional value,** *100 grams (g), cooked*

### POWER PODS

Chickpeas provide more than two times as much protein as corn and more than four times as much fiber as brown rice.



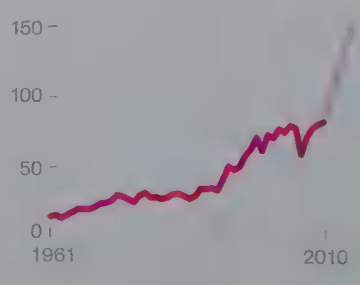
### BUG PROTEIN

They're nutritious, plentiful, and often crunchy. Grasshoppers, rhino beetles, and termites are just some of the more than one thousand species of insects eaten around the world. Most are foraged. But as food prices rise, bug farming may become a growth industry.

### THE HUMBLE SPUD

The world's top potato producer, China is pushing to develop disease-free seed potatoes and new varieties tailored to diverse climates as its population grows.

**Potato production in China,** *millions of tons*



PHOTOS: KIRIAKO IATRIDIS (TOP); DAVID LIITTSCHWAGER (LEFT); ERIC GREGORY POWELL. GRAPHICS: JASON TREAT, NGM STAFF
SOURCES: USDA; FAOSTAT; INTERNATIONAL POTATO CENTER

# Still thinking small.

Fifty years ago, when we first told the world to Think Small, it was about how a little car could have a huge impact. Since then, we've expanded that small thinking beyond the car to everything we do: from efficient-but-powerful* engines to the first LEED® Platinum-certified automotive plant. Because today, having a big impact means making a small one. It's called thinking blue and it means thinking beyond green. **That's the Power of German Engineering.**

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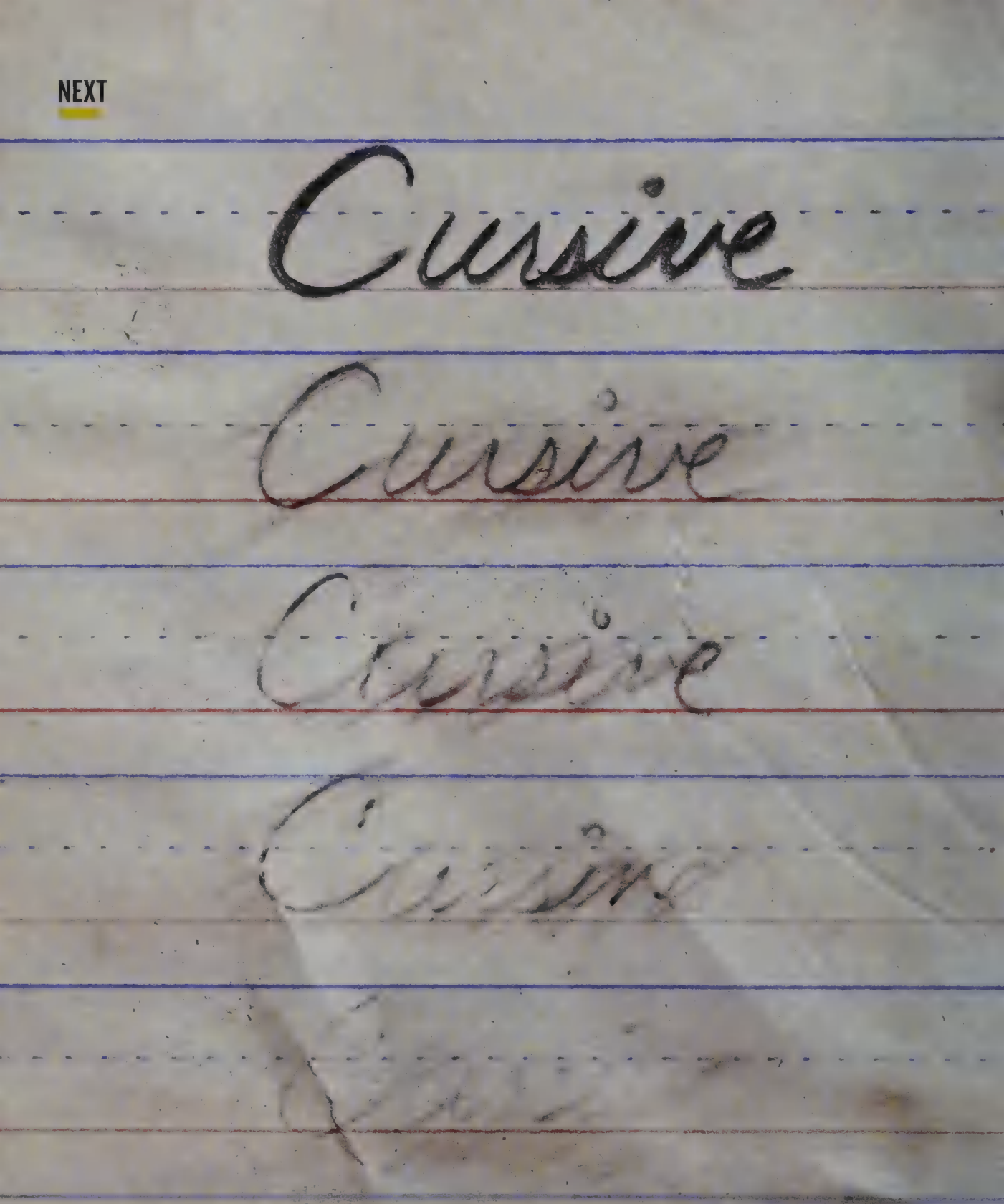
vw.com/thinkblue

*See www.fueleconomy.gov for EPA estimates. Your mileage will vary. ©2012 Volkswagen of America, Inc.




## Disappearing Act

The quill, fragile and prone to splattering, had limitations. Cursive's continuous paper contact solved the problem for U.S. first graders until the 1900s, when block print supplanted it. So began a slow shift as cursive classes slid to the third grade. By the mid-2000s, 88 percent of elementary teachers felt undertrained to teach cursive, and a 2010 survey showed 85 percent of collegians printed when they wrote.

As of the start of 2012, 45 states had adopted the Common Core State Standards for education, which include instruction in typing and use of digital tools for writing but leave out cursive altogether—"the start of the end," according to handwriting historian Steve Graham. A lost art, then? Not just cursive but all writing may be at risk. Pen and quill are fairly equivalent in modern classrooms, says Graham: "19th-century tools in a 21st-century writing world." *—Johnna Rizzo*

PHOTO: REBECCA HALE, NGM STAFF

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*Maps showing historical and projected areas where climate suits certain trees help foresters pick species for assisted-migration planning. British Columbia is evaluating 15 kinds, including lodgepole pine (above).*

# Future Forests

If global temperatures rise, can forests still flourish in their current ranges? Some scientists think not, so British Columbia—with assistance from the U.S. Forest Service—is now testing the climate tolerance of 15 common and commercially valuable tree species in non-native habitats. The aim: to identify ones that can be moved into areas expected to be more hospitable in the future.

Called assisted migration, the controversial approach presumes "evolution can't keep up with the rate of climate change, so it needs some help," says project head Greg O'Neill. Detractors of the increasingly studied forestry practice cite the risks of altering ecosystems.

British Columbia has already extended the legal range in which timber companies can plant western larch seedlings. Other species, including Douglas fir and lodgepole pine, are being tested at sites spanning 1,700 miles, from Canada's Yukon to California. These will be monitored for 30 years to evaluate their survival. "One day we could rely on Washington's seed, Washington on Oregon's, and so on," says O'Neill. "It's a problem that knows no geographic boundaries." *—Luna Shyr*

IN BRIEF

The Hubble Space Telescope revealed a **NEW TYPE OF PLANET** made largely of water, with a thick, steamy atmosphere. ▪ A **SPIDERWEB'S ABILITY** to withstand high stress is due partly to ■ design that allows a single filament to break away and leave the rest intact, say MIT scientists. ▪ A Russian team has reached the surface of a **MASSIVE SUBGLACIAL LAKE** in Antarctica after some three decades of drilling. ▪ A NASA-led study found that the **EARTH SPUN FASTER** during two weeks in 2009 due to a slowing ocean current.

PHOTO: REBECCA HALE, NGM STAFF. MAP: MAGGIE SMITH, NGM STAFF
SOURCE: TONGLI WANG, CENTRE FOR FOREST CONSERVATION GENETICS, UNIVERSITY OF BRITISH COLUMBIA

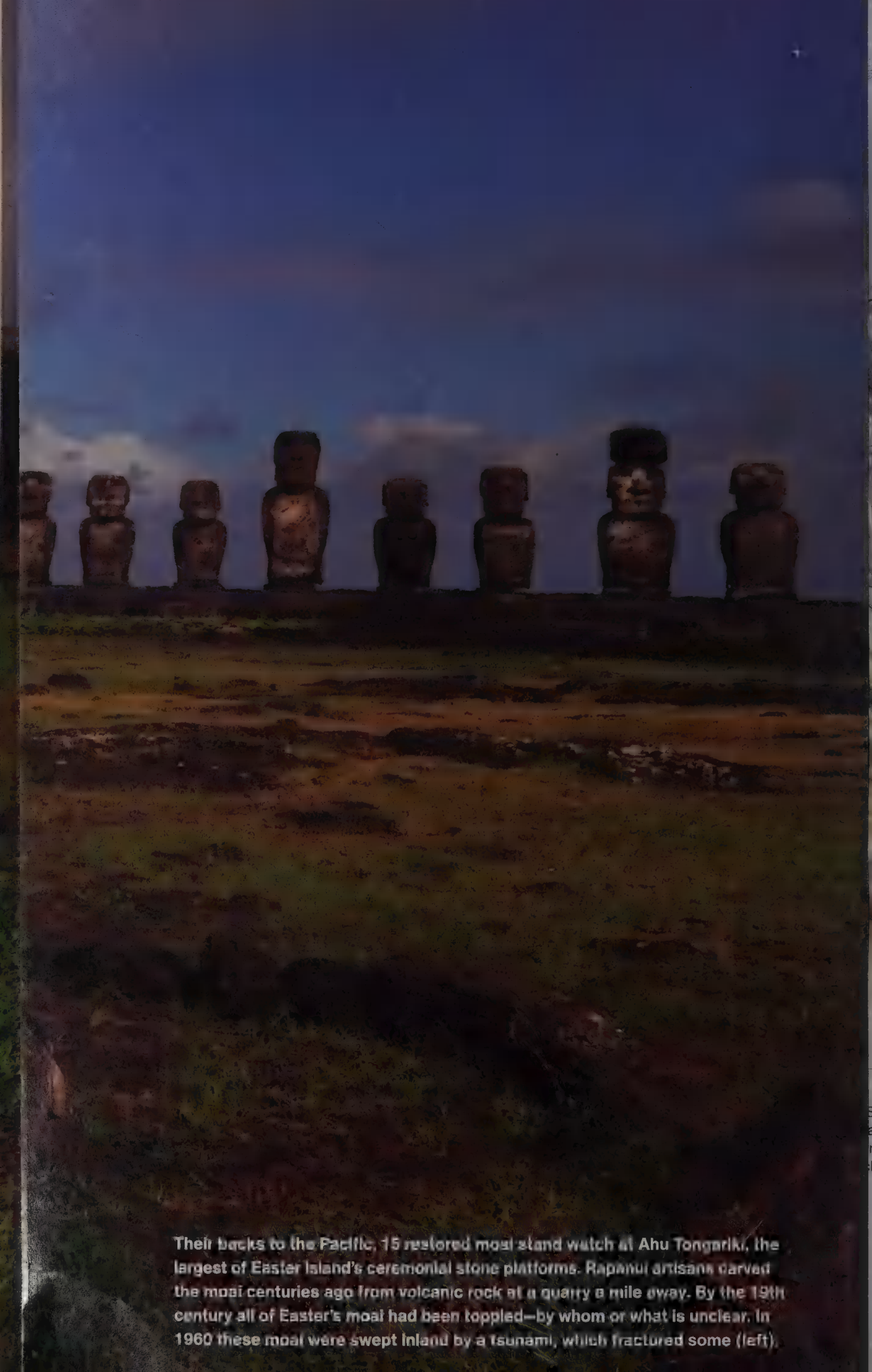
# If They Could Only Talk

*"The statues walked," Easter Islanders say. Archaeologists are still trying to figure out how—and whether their story is a cautionary tale of environmental disaster or a celebration of human ingenuity.*

BY HANNAH BLOCH

PHOTOGRAPHS BY RANDY OLSON

The ancient statues known as *moai* are everyday sights on Easter Island, or Rapa Nui—native dancers in body paint, less so. Some 2,000 Rapanui live on the island, which belongs to Chile. They numbered only 111 in 1877, after slave traders and disease had decimated the population.



Their backs to the Pacific, 15 restored moai stand watch at Ahu Tongariki, the largest of Easter Island's ceremonial stone platforms. Rapanui artisans carved the moai centuries ago from volcanic rock at a quarry a mile away. By the 19th century all of Easter's moai had been toppled—by whom or what is unclear. In 1960 these moai were swept inland by a tsunami, which fractured some (left).

# How Did They Move?

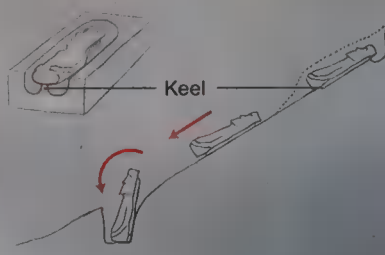
It's one of Easter Island's persistent mysteries: How were hundreds of giant statues transported across the island centuries ago, over distances as long as 11 miles, by people who lacked draft animals and wheels? The scene imagined here with a 21-foot-tall moai illustrates a new theory. It takes its cues from Rapanui oral tradition, which says the moai "walked."

## STATUES THAT ROC

**Terry Hunt, Carl Lip**

Archaeologists Hunt a
Lipo believe three sm
groups could have wa
a moai: Two groups c
it forward by rocking
to side, while a third
lized it from the back.

A D-shaped, heavy bottom made a moai rockable. In 2011 experiment, 18 people walked a 10-foot, 5-ton replica a few hundred yards.




At Rano Raraku, the main quarry, each moai was carved out of sloping bedrock until only a slender "keel" held it in place. The last step was to sever the keel and lower the moai downhill with ropes into a trench to await transport.

Dirt roads radiating from the quarry were constructed with gentle slopes to help moai reach their platforms in one piece.

## EARLIER THEORIES

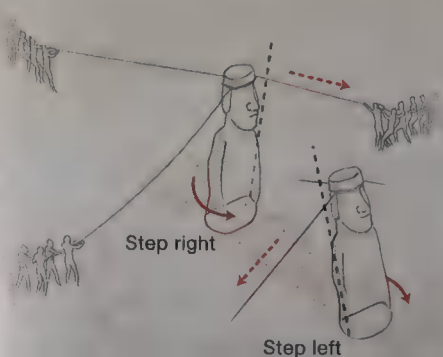
### Thor Heyerdahl, 1955

The Norwegian and a team of 180 strapped a real, 13-foot, 10-ton moai onto a tree trunk, then dragged it. "You are totally wrong, sir," a Rapanui onlooker told Heyerdahl.

### William Mulloy, 1970

Using a desktop model, this U.S. archaeologist speculated that a moai might be swung forward in steps while hanging by the neck from an inverted wooden V.

2011




FERNANDO G. BAPTISTA AND MATTHEW TWOMBLY, NGM STAFF; PATRICIA HEALY; DEBBIE GIBBONS, NG MAPS

White coral eyes with pupils of obsidian or red scoria were inserted after a moai reached its platform. They brought the stone face to life.

**iPad Exclusive**
See the statues walk on our iPad edition.

**Pavel Pavel, 1986**

Czech engineer Pavel, Heyerdahl, and 17 helpers walked a 13-foot, 9-ton moai—another real one—with a twisting rather than a rocking motion. They damaged the base.

**Charles Love, 1987**

U.S. archaeologist Love and his team of 25 stood a 13-foot, 9-ton replica on a wood sledge and hauled it over rollers. In two minutes, they moved it 148 feet.

**Jo Anne Van Tilburg, 1998**

Laying a 13-foot, 10-ton replica on a wood sledge, 40 volunteers pulled it 230 feet on a wood "ladder"—a Polynesian way of moving giant canoes.

SOURCES: TERRY L. HUNT, UNIVERSITY OF HAWAII; CARL LIPO, CALIFORNIA STATE UNIVERSITY LONG BEACH; HELENE MARTINSSON-WALLIN, GOTLAND UNIVERSITY; FRANCISCO TORRES HOCHSTETTER, RAPA NUI MUSEUM

JO ANNE VAN TILBURG, EASTER ISLAND STATUE PROJECT

# On a winter night last June,

José Antonio Tuki, a 30-year-old artist on Easter Island, did one of the things he loves best: He left his one-room home on the southwest coast and hiked north across the island to Anakena beach. Legend has it the earliest Polynesian settlers hauled their canoes ashore at Anakena a thousand years ago or so, after navigating more than a thousand miles of open Pacific. Under the same moon and stars Tuki sat on the sand and gazed directly before him at the colossal human statues—the *moai.* Carved centuries ago from volcanic tuff, they're believed to embody the deified spirits of ancestors.

Sleepless roosters crowed; stray dogs barked. A frigid wind gusted in from Antarctica, making Tuki shiver. He's a Rapanui, an indigenous Polynesian resident of Rapa Nui, as the locals call Easter Island; his own ancestors probably helped carve some of the hundreds of statues that stud the island's grassy hills and jagged coasts. At Anakena seven potbellied moai stand at attention on a 52-foot-long stone platform—backs to the Pacific, arms at their sides, heads capped with tall *pukao* of red scoria, another volcanic rock. They watch over this remote island from a remote age, but when Tuki stares at their faces, he feels a surge of connection. "It's something strange and energetic," he says. "This is something produced from my culture. It's Rapanui." He shakes his head. "How did they do it?"

Easter Island covers just 63 square miles. It lies 2,150 miles west of South America and 1,300 miles east of Pitcairn, its nearest inhabited neighbor. After it was settled, it remained isolated for

**The one-room house that José Antonio Tuki built on Easter Island for himself and his Belgian girlfriend, Joyce Verbaenen, has electricity but no indoor plumbing. The ocean is only steps away.**

---

*Hannah Bloch was a Pakistan correspondent for* Time *before joining the* Geographic *as an editor. Randy Olson has shot 27 features, including ones on war-torn Sudan and Congo's Mbuti Pygmies.*

centuries. All the energy and resources that went into the moai—which range in height from four to 33 feet and in weight to more than 80 tons—came from the island itself. Yet when Dutch explorers landed on Easter Sunday in 1722, they met a Stone Age culture. The moai were carved with stone tools, mostly in a single quarry, then transported without draft animals or wheels to massive stone platforms, or *ahu,* up to 11 miles away. Tuki's question—how did they do it?—has vexed legions of visitors in the past half century.

But lately the moai have been drawn into a larger debate, one that opposes two distinct visions of Easter Island's past—and of humanity in general. The first, eloquently expounded by Pulitzer Prize winner Jared Diamond, presents the island as a cautionary parable: the most extreme case of a society wantonly destroying itself by wrecking its environment. Can the whole planet, Diamond asks, avoid the same fate? In the other view, the ancient Rapanui are uplifting emblems of human resilience and ingenuity—one example being their ability to walk giant statues upright across miles of uneven terrain.

WHEN THE POLYNESIAN SETTLERS arrived at Rapa Nui, they had been at sea for weeks in open canoes. There were probably only a few dozen

of them. Nowadays 12 flights arrive every week from Chile, Peru, and Tahiti, and in 2011 those planes delivered 50,000 tourists, ten times the island's population. Just three decades ago, cars, electricity, and phone service were scarce; now Hanga Roa, the only town, buzzes with Internet cafés, bars, and dance clubs, and cars and pickup trucks clog the streets on Saturday nights. Wealthy tourists drop a thousand dollars a night at the poshest of scores of hotels. A Birkenstock shop caters to footsore ramblers. "The island is not an island anymore," says Kara Pate, 40, a Rapanui sculptor. She's married to a German she met here 23 years ago.

Chile annexed Easter Island in 1888, but until 1953 it allowed a Scottish company to manage the island as a giant sheep ranch. The sheep ranged freely, while the Rapanui were penned into Hanga Roa. In 1964 they revolted, later obtaining Chilean citizenship and the right to elect their own mayor.

Ambivalence toward *el conti* (the continent) runs high. Easter Islanders depend on Chile for fuel and daily air shipments of food. They speak Spanish and go to the mainland for higher education. Meanwhile, Chilean migrants, lured in part by the island's income tax exemption, gladly take jobs that Rapanui spurn. "A Rapanui will

**Three volcanoes, quiet now, formed Easter Island half a million years ago. It has three crater lakes but no streams; fresh water is scarce. Chile, the island's source of fuel and most food, is 2,150 miles away.**

say, What, you think I'm going to wash dishes?" says Beno Atán, a 27-year-old tour guide and a native himself. Though many Rapanui have married mainlanders, some worry their culture is being diluted. The population is now around 5,000, nearly double what it was 20 years ago, and fewer than half the people are Rapanui.

Just about every job on Easter Island depends on tourism. "Without it," says Mahina Lucero Teao, head of the tourism chamber, "everyone would be starving on the island." The mayor, Luz Zasso Paoa, says, "Our patrimony is the base of our economy. You're not here for us, but for that patrimony." That is, for the moai.

THOR HEYERDAHL, the Norwegian ethnographer and adventurer whose Pacific expeditions helped ignite the world's curiosity about Easter Island, thought the statues had been created by pre-Inca from Peru, not by Polynesians. Erich von Däniken, the best-selling Swiss author of *Chariots of the Gods,* was sure the moai were built by stranded extraterrestrials. Modern science—linguistic, archaeological, and genetic evidence—has proved the moai builders were Polynesian but not how they moved their creations. Researchers have tended to assume the ancestors dragged the statues somehow, using a lot of ropes and wood. "The experts can say whatever they want," says Suri Tuki, 25, José Tuki's half brother. "But we know the truth. The statues walked." In the Rapanui oral tradition, the moai were animated by *mana,* a spiritual force transmitted by powerful ancestors.

There are no reports of moai building after Europeans arrived in the 18th century. By then Easter Island had only a few scrawny trees. In the 1970s and 1980s, though, biogeographer John Flenley of New Zealand's Massey University found evidence—pollen preserved in lake sediments—that the island had been covered in lush forests, including millions of giant palm trees, for thousands of years. Only after the Polynesians arrived around A.D. 800 had those forests given way to grasslands.

Jared Diamond drew heavily on Flenley's work for his assertion in *Collapse,* his influential 2005

Tourists diving on Easter Island's reef encounter a fake moai, made for a 1994 Hollywood movie and then sunk offshore. The reef is healthy, though it is overfished. Tuna and salmon are imported, primarily for tourists.

*The loss of Easter Island's forests was an "ecological catastrophe"—but the islanders were not to blame, the new theory says. And the moai certainly weren't.*

book, that ancient Easter Islanders committed unintentional ecocide. They had the bad luck, Diamond argues, to have settled an extremely fragile island—dry, cool, and remote, which means it's poorly fertilized by windblown dust or volcanic ash. (Its own volcanoes are quiescent.) When the islanders cleared the forests for firewood and farming, the forests didn't grow back. As wood became scarce and the islanders could no longer build seagoing canoes for fishing, they ate the birds. Soil erosion decreased their crop yields. Before Europeans showed up, the Rapanui had descended into civil war and cannibalism. The collapse of their isolated civilization, Diamond writes, is "the clearest example of a society that destroyed itself by overexploiting its own resources" and "a worst-case scenario for what may lie ahead of us in our own future."

The moai, he thinks, accelerated the self-destruction. Diamond interprets them as power displays by rival chieftains who, trapped on a remote little island, lacked other ways of strutting their stuff. They competed by building ever bigger statues. Diamond thinks they laid the moai on wooden sledges, hauled over log rails—a technique successfully tested by UCLA archaeologist Jo Anne Van Tilburg, director of the Easter Island Statue Project—but that required both a lot of wood and a lot of people. To feed the people, even more land had to be cleared. When the wood was gone and civil war began, the islanders began toppling the moai. By the 19th century none were standing. Easter Island's landscape acquired the aura of tragedy that, in the eyes of Diamond and many others, it retains today.

REARRANGE AND REINTERPRET the scattered shards of fact, though, and you get a more optimistic vision of the Rapa Nui past—that of archaeologists Terry Hunt of the University of Hawaii and Carl Lipo of California State University Long Beach, who have studied the island for the past decade. It's a vision peopled by peaceful, ingenious moai builders and careful stewards of the land. Hunt and Lipo agree that Easter Island lost its lush forests and that it was an "ecological catastrophe"—but the islanders themselves weren't to blame. And the moai certainly weren't. There is indeed much to learn from Easter Island, Hunt says, "but the story is different."

His and Lipo's controversial new version, based on their research and others', begins with their own excavation at Anakena beach. It has convinced them that the Polynesians didn't arrive until A.D. 1200, about four centuries later than is commonly understood, which would leave them only five centuries to denude the landscape. Slashing and burning wouldn't have been enough, Hunt and Lipo think. Anyway, another tree killer was present. When archaeologists dig up nuts from the extinct Easter Island palm, the nuts are often marred by tiny grooves, made by the sharp teeth of Polynesian rats.

The rats arrived in the same canoes as the first settlers. Abundant bones in the Anakena dig suggest the islanders dined on them, but otherwise the rodents had no predators. In just a few years, Hunt and Lipo calculate, they would have overrun the island. Feasting on palm nuts, they would have prevented the reseeding of the slow-growing trees and thereby doomed Rapa Nui's forest, even if humans hadn't been slashing and burning. No doubt the rats ate birds' eggs too.

Of course, the settlers bear responsibility for bringing the rats; Hunt and Lipo suspect they did so intentionally. (They also brought chickens.) But like invasive species today, the Polynesian rats did more harm to the ecosystem than to the humans who transported them. Hunt and Lipo see no evidence that Rapanui civilization collapsed when the palm forest did; based on their own archaeological survey of the island, they think its population grew rapidly after settlement to around 3,000 and then remained more or less stable until the arrival of Europeans.

Cleared fields were more valuable to the

**Chilean newlyweds in festive paint and feathers (at right) celebrate marriage Rapanui style. Nearly two-thirds of the 50,000 visitors to the island in 2011 were from Chile.**

Rapanui than palm forests were. But they were wind-lashed, infertile fields watered by erratic rains. Easter Island was a tough place to make a living. It required heroic efforts. In farming, as in moai moving, the islanders shifted monumental amounts of rock—but into their fields, not out. They built thousands of circular stone windbreaks, called *manavai,* and gardened inside them. They mulched whole fields with broken volcanic rocks to keep the soil moist and fertilized it with nutrients that the volcanoes were no longer spreading. In short, Hunt, Lipo, and others contend, the prehistoric Rapanui were pioneers of sustainable farming, not inadvertent perpetrators of ecocide. "Rather than a case of abject failure, Rapa Nui is an unlikely story of success," Hunt and Lipo argue in their recent book.

It's called *The Statues That Walked,* and the Rapanui enjoy better spin in it than they do in *Collapse.* Hunt and Lipo don't trust oral history accounts of violent conflict among the Rapanui; sharp obsidian flakes that other archaeologists see as weapons, they see as farm tools. The moai helped keep the peace, they argue, not only by signaling the power of their builders but also by limiting population growth: People raised statues rather than children. What's more, moving the moai required few people and no wood, because they were walked upright. On that issue, Hunt and Lipo say, evidence supports the folklore.

Sergio Rapu, 63, a Rapanui archaeologist and former Easter Island governor who did graduate work with Hunt, took his American colleagues to the ancient quarry on Rano Raraku, the island's southeastern volcano. Looking at the many moai abandoned there in various stages of completion, Rapu explained how they were engineered to walk: Fat bellies tilted them forward, and a D-shaped base allowed handlers to roll and rock them side to side. Last year, in experiments funded by National Geographic's Expeditions Council, Hunt and Lipo showed that as few as 18 people could, with three strong ropes and a bit of practice, easily maneuver a 10-foot, 5-ton moai

**Society Grant** Terry Hunt and Carl Lipo's moai experiment was funded by your Society membership.

replica a few hundred yards. In real life, walking miles with much larger moai would have been a tense business. Dozens of fallen statues line the roads leading away from the quarry. But many more made it to their platforms intact.

No one knows for sure when the last statue was carved. The moai cannot be dated directly. Many were still standing when the Dutch arrived in 1722, and Rapanui civilization was peaceful and thriving then, Hunt and Lipo argue. But the explorers introduced deadly diseases to which islanders had no immunity, along with artifacts that replaced the moai as status symbols. Snatching Europeans' hats—Hunt and Lipo cite many reports of this—became more appealing than hoisting a multiton red pukao onto a moai. In the 19th century slave traders decimated the population, which shriveled to 111 people by 1877.

As Hunt and Lipo tell it, Easter Island's story is a parable of genocide and culturecide, not ecocide. Their friend Sergio Rapu buys some but not all of it. "Don't tell me those obsidian tools were just for agriculture," he says, laughing. "I'd love to hear that my people never ate each other. But I'm afraid they did."

TODAY ISLANDERS confront a fresh challenge: exploiting their cultural legacy without wrecking it. A growing population and thousands of tourists are straining a limited water supply. The island lacks a sewer system and a place to put the swelling volume of trash; between 2009 and mid-2011 it shipped 230 tons to the mainland. "So what do we do?" asks Zasso Paoa, the mayor. "Limit migration? Limit tourism? That's where we are now." The island recently started asking tourists to take their trash home with them in their suitcases.

Tourists are forbidden to touch moai, but horses happily rub against them, wearing away the porous tuff. Though cars are now the preferred mode of transport, more than 6,000 horses and cattle—"more than people," grumbles tour guide Atán—still run free, trampling ground once trodden by Scottish-owned sheep and relieving themselves on once sacred platforms. But the islanders' own desire to develop

**Isolated no more, seductive but not easy, Rapa Nui holds its people. José Tuki (at left, with girlfriend, Joyce) moved to Chile, but only for four years. "If you go away," he says, "the island will call you back."**

their ancestral lands may be a greater threat to their densely packed heritage: more than 20,000 archaeological features in all, including walled gardens and stone chicken houses as well as moai and ahu. More than 40 percent of the island is a protected national park, which limits available land. "People have to learn that archaeology isn't their enemy," says Rapu.

Decades ago he himself helped get the moai at Anakena back upright. In the process he and his colleagues also discovered how the moai builders had breathed soul into their colossal statues after the long trek from the quarry: As a finishing touch, they placed eyes of white coral and pupils of obsidian or red scoria into the empty sockets.

A grove of coconut palms, imported from Tahiti, overlooks Anakena beach today, reassuring sunbathers and Chilean newlyweds that they really are in Polynesia, even if the wind is shrieking and the grassy rolling hills behind them look like the Scottish Highlands. The moai are eyeless now and not confiding—to the tourists, José Tuki, or anyone else—how they got there or which story of Easter Island is true. Tuki, for one, can handle the ambiguity. "I want to know the truth," he says. "But maybe the island doesn't tell all its answers. And maybe knowing everything would take its power away." □

# EPIC STORMS

*Photographs by Mitch Dobrowner*

*Forming a mushroom head, a monsoon thunderstorm drops a deluge on the desert. The base of this cloud may hang some two miles above the ground.* LORDSBURG, NEW MEXICO

"SOME THINGS YOU LEARN BEST IN CALM," wrote author Willa Cather, scribe of the Great Plains, "and some in storm." She wasn't referring to the local weather, but she might as well have been. Each year the American heartland offers a graduate course in natural tumult. From March to October these flatlands play host to thousands of visible, violent storms. Meteorology and topography conspire to paint blusterous murals and apocalyptic tableaux.

When dry air from the Rockies slides over

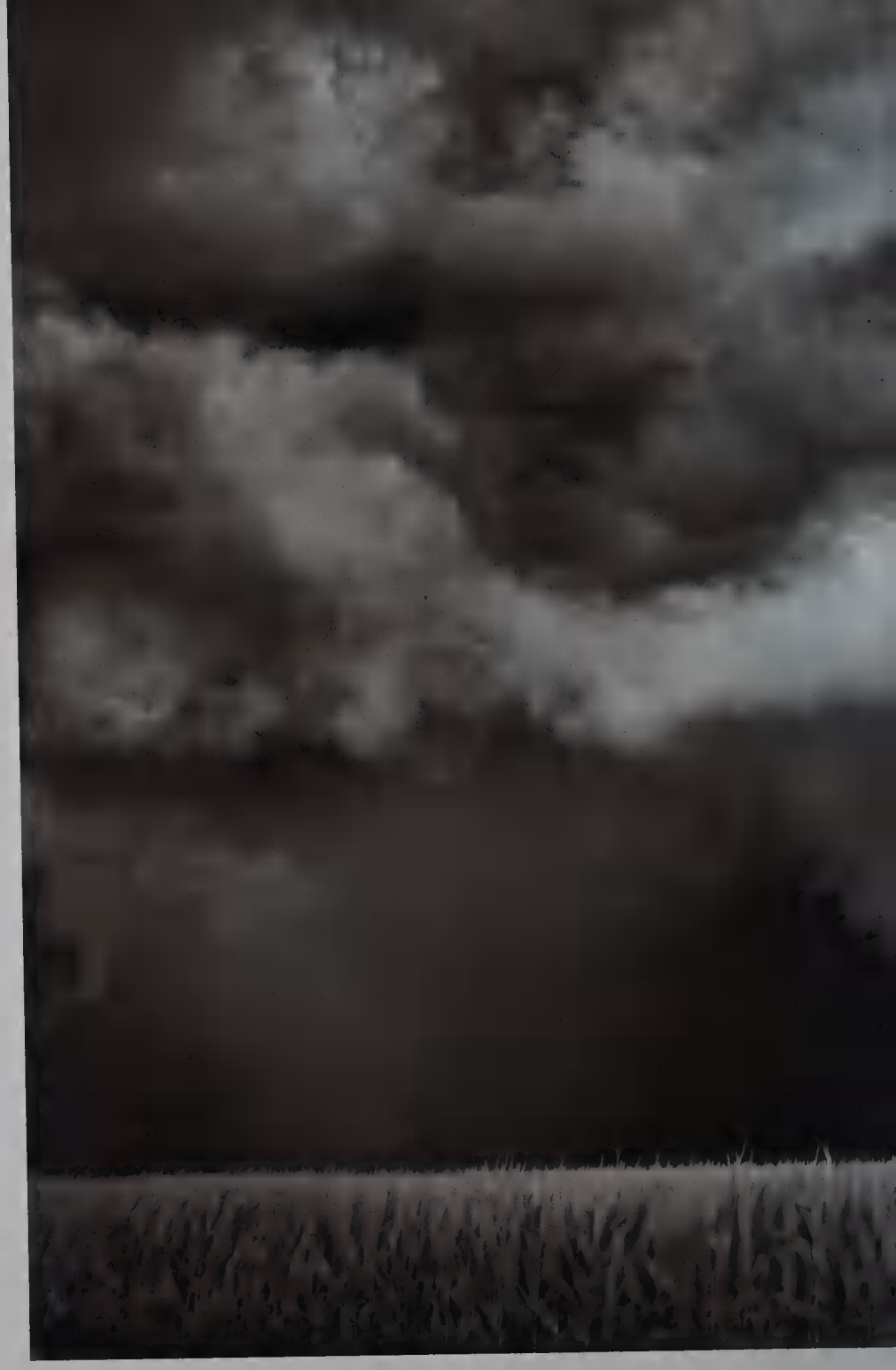
*A dying tornado like this one is said to be in the "roping out" phase.* REGAN, NORTH DAKOTA

moist air from the Gulf of Mexico, the stage is set for a storm. The burst may expel rain and hail, thunder and lightning, wind and funnel. It may kill people and animals, destroy crops and property, flood roads and towns. (The National Weather Service reports scores of storm-related deaths every year. In 2011, says the insurance industry, U.S. thunderstorms caused some $26 billion in damage.) Yet a storm giveth too, delivering rain to parched fields, wind to inert turbines, lightning-produced nitrogen to nutrient-starved soil.

To document these awe-inspiring tempests, Mitch Dobrowner, a landscape photographer inspired by Ansel Adams and Minor White, teamed with renowned storm chaser Roger Hill, a witness to more than 600 tornadoes. Over the past three years, aided by mobile satellite data, radar imaging, and more, the pair have stalked

*It's not a hovering spaceship. It's a low-precipitation supercell—"one of the prettiest sights in the severe-weather world," says storm chaser Roger Hill. Photographer Mitch Dobrowner says they tracked this one 300 miles from the Texas Panhandle.* NEAR CLAYTON, NEW MEXICO

*Most storms move fast. This one crept over a farming community for more than an hour, bristling with electricity. "No two storms are the same," says James LaDue, a meteorologist at the National Weather Service. "No two skies are either."* NEAR GUYMON, OKLAHOMA



some 45 weather systems over 16 states and 40,000 miles, sometimes driving 900 miles in a day to capture a moment. "With storms," says Dobrowner, "it's like shooting a sporting event. Things happen so quickly, I really have to adapt."

Working in black and white—"Color seems too everyday," he says—he looks especially for supercells, rarest and mightiest of thunderstorms. A classic one, says Hill, "is the most violent, prolific tornado-producing machine there is." Its recipe requires four ingredients: moisture,

*More of Mitch Dobrowner's work can be seen at* mitchdobrowner.com *and in his two books, published by 21st Editions.*

***Born in a bruising supercell, a funnel cloud looms beyond a cornfield.*** NORTHFIELD, MINNESOTA

atmospheric instability, something to lift the air, and vertical wind shear to rotate the storm.

When those elements align, an erratic, uniquely structured storm appears. Powered by a strong, rotating updraft, a supercell can steer itself away from the prevailing wind, devour or destroy other squalls in its path, and dodge its own storm-extinguishing precipitation, staying alive for up to 12 hours.

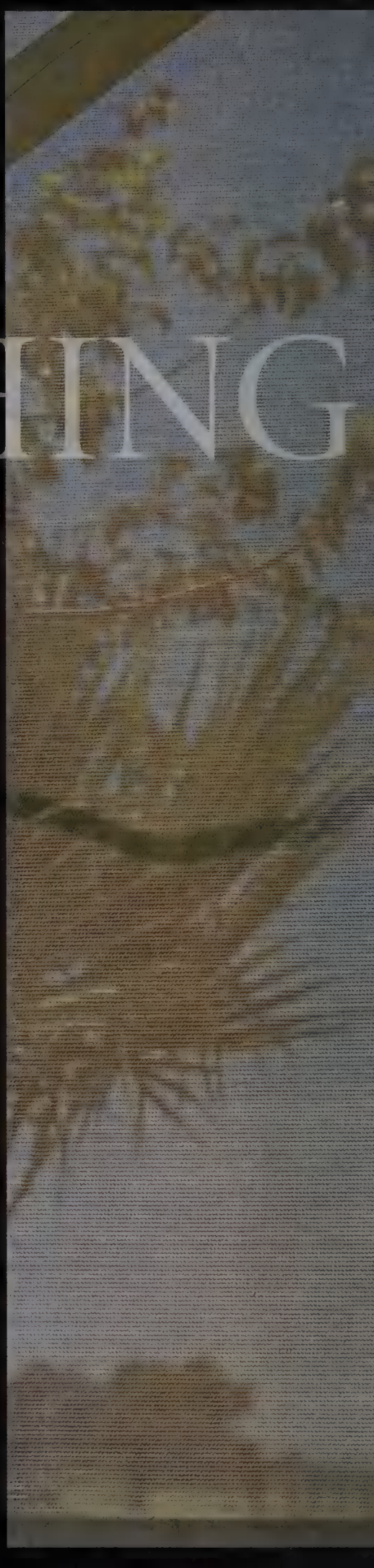
Indeed, both Dobrowner and Hill see supercells as living things: born under the right conditions, gaining strength as they grow, changing shape and form, fighting for their life, eventually dying. Not that personifying them removes the danger. In the still wild West, says Hill, storms demand admiration and respect. "I feel honored to be shooting them," says Dobrowner. "If I'm going to go, let me go like this." *—Jeremy Berlin*

BY RUSS RYMER

PHOTOGRAPHS
BY LYNN JOHNSON

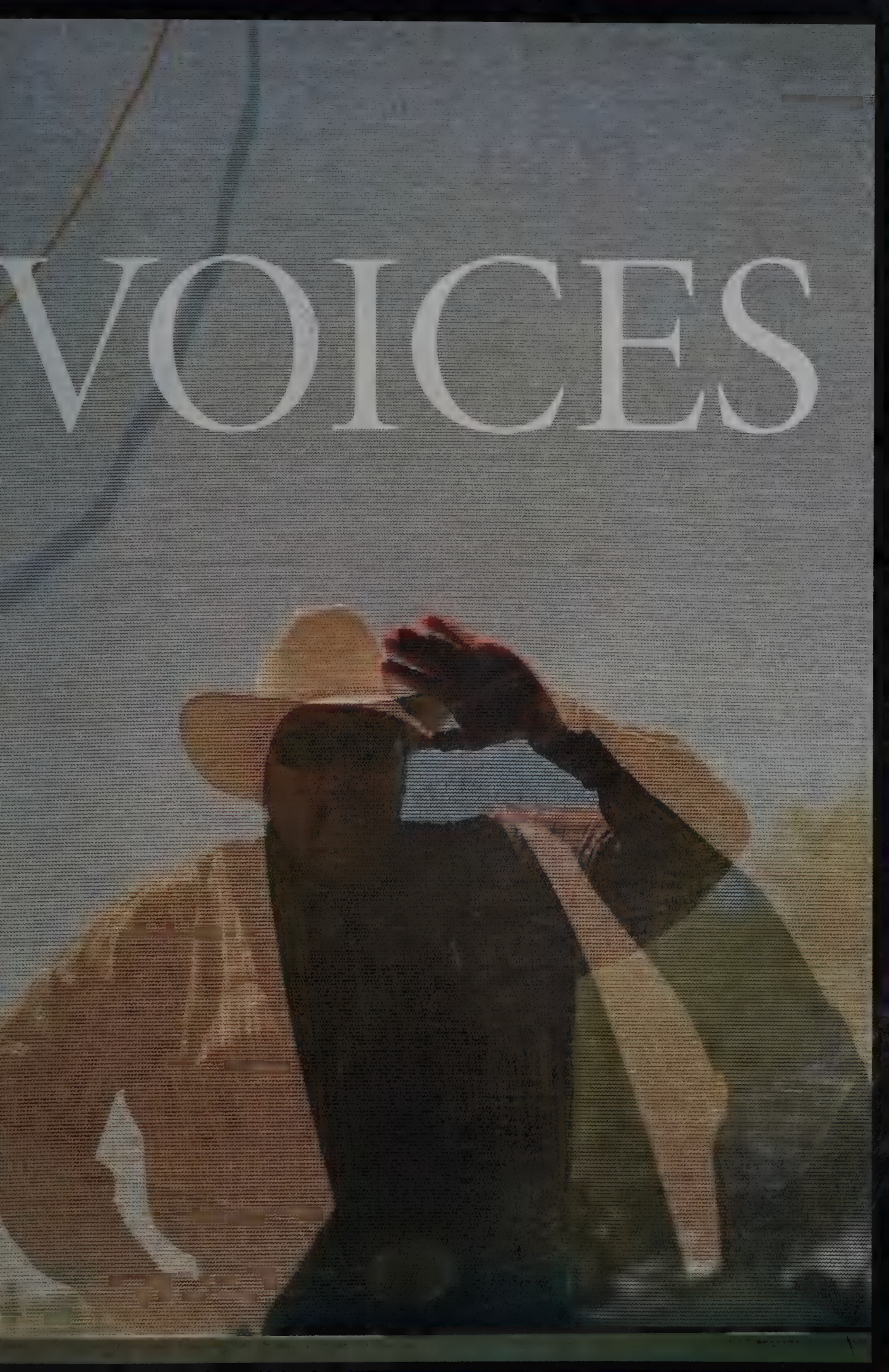
# VANISHING

One language dies every 14 days. By the next century nearly half of the roughly 7,000 languages spoken on Earth will likely disappear, as communities abandon native tongues in favor of English, Mandarin, or Spanish. What is lost when a language goes silent?



*Johnny Hill, Jr., of Parker, Arizona, is one of the last speakers of Chemehuevi, an endangered Native American language. "It's like a bird losing feathers. You see one float by, and there it goes—another word gone."*

# VOICES



TUVAN

## *THE COMPASSION OF KHOJ ÖZEERI*

ONE MORNING in early fall Andrei Mongush and his parents began preparations for supper, selecting a black-faced, fat-tailed sheep from their flock and rolling it onto its back on a tarp outside their livestock paddock. The Mongush family's home is on the Siberian taiga, at the edge of the endless steppes, just over the horizon from Kyzyl, the capital of the Republic of Tuva, in the Russian Federation. They live near the geographic center of Asia, but linguistically and personally, the family inhabits a borderland, the frontier between progress and tradition. Tuvans are historically nomadic herders, moving their *aal*—an encampment of yurts—and their sheep and cows and reindeer from pasture to pasture as the seasons progress. The elder Mongushes, who have returned to their rural aal after working in the city, speak both Tuvan and Russian. Andrei and his wife also speak English, which they are teaching themselves with pieces of paper labeled in English pasted onto seemingly every object in their modern kitchen in Kyzyl. They work as musicians in the Tuvan National Orchestra, an ensemble that uses traditional Tuvan instruments and melodies in symphonic arrangements. Andrei is a master of the most characteristic Tuvan music form: throat singing, or *khöömei.*

When I ask university students in Kyzyl what Tuvan words are untranslatable into English or Russian, they suggest khöömei, because the singing is so connected with the Tuvan environment that only a native can understand it, and also *khoj özeeri,* the Tuvan method of killing a sheep. If slaughtering livestock can be seen as part of humans' closeness to animals, khoj özeeri represents an unusually intimate version. Reaching through an incision in the sheep's hide, the slaughterer severs a vital artery with his fingers, allowing the animal to quickly slip away without alarm, so peacefully that one must check its eyes to see if it is dead. In the language of the Tuvan people, khoj özeeri means not only slaughter but also kindness, humaneness, a ceremony by which a family can kill, skin, and butcher a sheep, salting its hide and preparing its meat and making sausage with the saved blood and cleansed entrails so neatly that the whole thing can be accomplished in two hours (as the Mongushes did this morning) in one's good clothes without spilling a drop of blood. Khoj özeeri implies a relationship to animals that is also a measure of a people's character. As one of the students explained, "If a Tuvan killed an animal the way they do in other places"—by means of a gun or knife—"they'd be arrested for brutality."

Tuvan is one of the many small languages of the world. The Earth's population of seven billion people speaks roughly 7,000 languages, a statistic that would seem to offer each living language a healthy one million speakers, if things were equitable. In language, as in life, things aren't. Seventy-eight percent of the world's population speaks the 85 largest languages, while the 3,500 smallest languages share a mere 8.25 million speakers. Thus, while English has 328 million first-language speakers, and Mandarin 845 million, Tuvan speakers in Russia number just 235,000. Within the next century, linguists think, nearly half of the world's current stock of languages may disappear. More than a thousand are listed as critically or severely endangered—teetering on the edge of oblivion.

In an increasingly globalized, connected, homogenized age, languages spoken in remote places are no longer protected by national borders or natural boundaries from the languages that dominate world communication and commerce. The reach of Mandarin and English and Russian and Hindi and Spanish *(Continued on page 70)*



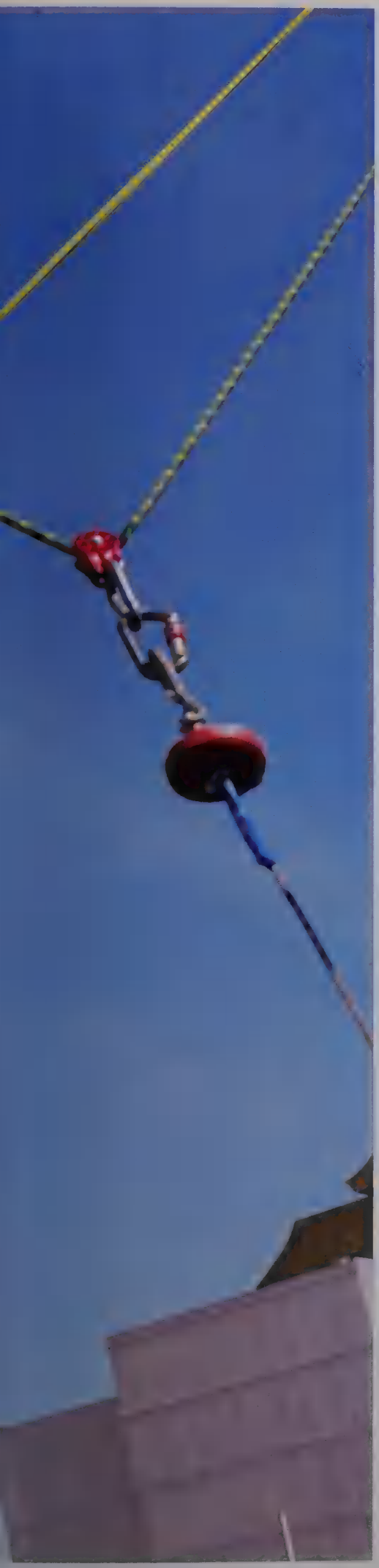
NGM MAPS

TUVAN

# [ artyštaar ]

to burn juniper | to purify

*A Tuvan shaman cleanses the house of a deceased relative's spirit using smoke from burning juniper to chase away darkness. The incense fills the room as the family ask the spirits of hearth and home to protect them.*



# TUVAN

LANGUAGE

*Russia*

*Number of speakers*

235,000

[ songgaar ]

go back | the future

[ burungaar ]

go forward | the past

*Tuvans believe the past is ahead of them while the future lies behind. The children who flock to this bungee-cord ride outside the National Museum of Tuva look to the future, but it's behind them, not yet seen.*

TUVAN

# [ ezenggileer ]

to stirrup | to sing with the rhythms of riding a horse

*The words used to describe styles of throat singing—an art among Tuvan herders—perfectly capture their distinctive sounds.* Ezenggileer *evokes the pulsing rhythms of galloping on a horse.*

TUVAN

# [ khei-àt ]

air horse | a spiritual place within

*Ai-Xaan Oorzhak throat sings and plays the* igil, *or horse-head fiddle, with bow techniques like "make horse walk." Singers use the term "air horse" to describe the spiritual depths they draw from to produce the harmonic sounds.*

TUVAN

# [ anayim ]

my little goat

*Aidyng Kyrgys caresses his newborn baby girl, whom he refers to using this tender term of endearment. The arrival of an infant is cause for a celebration and feasting for the whole family at their tiny log house.*

TUVAN

# [ ak byzaa ]

white calf, less than one year

*Raising sheep, yaks, and goats on the Siberian steppe is so central to Tuvan life that the vocabulary for livestock is embedded with detailed information about each animal's age, gender, fertility, coloration.*

and Arabic extends seemingly to every hamlet, where they compete with Tuvan and Yanomami and Altaic in a house-to-house battle. Parents in tribal villages often encourage their children to move away from the insular language of their forebears and toward languages that will permit greater education and success.

Who can blame them? The arrival of television, with its glamorized global materialism, its luxury-consumption proselytizing, is even more irresistible. Prosperity, it seems, speaks English. One linguist, attempting to define what a language is, famously (and humorously) said that a language is a dialect with an army. He failed to note that some armies are better equipped than others. Today any language with a television station and a currency is in a position to obliterate those without, and so residents of Tuva must speak Russian and Chinese if they hope to engage with the surrounding world. The incursion of dominant Russian into Tuva is evident in the speaking competencies of the generation of Tuvans who grew up in the mid-20th century, when it was the fashion to speak, read, and write in Russian and not their native tongue.

Yet Tuvan is robust relative to its frailest counterparts, some of which are down to a thousand speakers, or a mere handful, or even one individual. Languages like Wintu, a native tongue in California, or Siletz Dee-ni, in Oregon, or Amurdak, an Aboriginal tongue in Australia's Northern Territory, retain only one or two fluent or semifluent speakers. A last speaker with no one to talk to exists in unspeakable solitude.

Increasingly, as linguists recognize the magnitude of the modern language die-off and rush to catalog and decipher the most vulnerable tongues, they are confronting underlying questions about languages' worth and utility. Does each language have boxed up within it some irreplaceable beneficial knowledge? Are there aspects of cultures that won't survive if they are translated into a dominant language? What unexpected insights are being lost to the world with the collapse of its linguistic variety?

Fortunately, Tuvan is not among the world's endangered languages, but it could have been. Since the breakup of the Soviet Union, the language has stabilized. It now has a well-equipped army—not a television station, yet, or a currency, but a newspaper and a respectable 264,000 total speakers (including some in Mongolia and China). Yet Tofa, a neighboring Siberian language, is down to some 30 speakers. Tuvan's importance to our understanding of disappearing languages lies in another question linguists are struggling to answer: What makes one language succeed while another dwindles or dies?

AKA

## *THE RESPECT OF MUCROW*

I WITNESSED the heartrending cost of broken languages among the Aka people in Palizi, a tiny, rustic hamlet perched on a mountainside in Arunachal Pradesh, India's rugged northeasternmost state. It is reachable by a five-hour drive through palm and hardwood jungles on single-track mountain roads. Its one main street is lined with unpainted board-faced houses set on stilts and roofed with thatch or metal. Villagers grow their own rice, yams, spinach, oranges, and ginger; slaughter their own hogs and goats; and build their own houses. The tribe's isolation has bred a radical self-sufficiency, evidenced in an apparent lack of an Aka word for job, in the sense of salaried labor.

The Aka measure personal wealth in mithan, a breed of Himalayan cattle. A respectable bride price in Palizi, for instance, is expressed as eight mithan. The most cherished Aka possession is the precious *tradzy* necklace—worth two mithan—made from yellow stones from the nearby river, which is passed down to their children.

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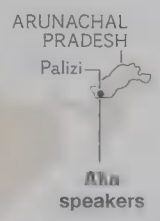
*Russ Rymer is the author of* Genie: A Scientific Tragedy, *the story of an abused child whose case helped scientists study the acquisition of language. Photographer Lynn Johnson's last feature for the magazine was on the trail of the Apostles.*

*o words for specific numbers but gets by using "few" or "many."*

The yellow stones for the tradzy necklaces can no longer be found in the river, and so the only way to have a precious necklace is to inherit one.

Speaking Aka—or any language—means immersing oneself in its character and concepts. "I'm seeing the world through the looking glass of this language," said Father Vijay D'Souza, who was running the Jesuit school in Palizi at the time of my visit. The Society of Jesus established the school in part because it was concerned about the fragility of the Aka language and culture and wanted to support them (though classes are taught in English). D'Souza is from southern India, and his native language is Konkani. When he came to Palizi in 1999 and began speaking Aka, the language transformed him.

"It alters your thinking, your worldview," he told me one day in his headmaster's office, as children raced to classes through the corridor outside. One small example: *mucrow.* A similar word in D'Souza's native language would be an insult, meaning "old man." In Aka "mucrow" means something more. It is a term of respect, deference, endearment. The Aka might address a woman as mucrow to indicate her wisdom in civic affairs, and, says D'Souza, "an Aka wife will call her husband mucrow, even when he's young," and do so affectionately.




American linguists David Harrison and Greg Anderson have been coming to Arunachal Pradesh to study its languages since 2008. They are among the scores of linguists worldwide engaged in the study of vanishing languages. Some have academic and institutional affiliations (Harrison and Anderson are both connected with National Geographic's Enduring Voices Project), while others may work for Bible societies that translate Scripture into new tongues. The authoritative index of world languages is *Ethnologue,* maintained by SIL International, a faith-based organization. The researchers' intent may be hands-off, to record a grammar and lexicon before a language is lost or contaminated, or it may be interventionist, to develop a written accompaniment for the oral language, compile a dictionary, and teach native speakers to write.

Linguists have identified a host of language hotspots (analogous to biodiversity hotspots) that have both a high level of linguistic diversity and a high number of threatened languages (see map, pages 92-3). Many of these are in the world's least reachable, and often least hospitable, places—like Arunachal Pradesh. Aka and its neighboring languages have been protected because Arunachal Pradesh has long been sealed off to outsiders as a restricted border region. Even other Indians are not allowed to cross into the region without federal permission, and so its fragile microcultures have been spared the intrusion of immigrant labor, modernization—and linguists. It has been described as a black hole of linguistics because its incredible language variety remains so little explored.

Much of public life in Palizi is regulated through the repetition of mythological stories used as forceful fables to prescribe behavior. Thus a money dispute can draw a recitation about a spirit whose daughters are eaten by a crocodile, one by one, as they cross the river to bring him dinner in the field. He kills the crocodile, and a priest promises to bring the last daughter back to life but overcharges so egregiously that the spirit seeks revenge by becoming a piece of ginger that gets stuck in the greedy priest's throat.

Such stories were traditionally told by the elders in a highly formal version of Aka that the young did not yet understand and according to certain rules, among them this: Once an elder begins telling a story, he cannot stop until the story is finished. As with linguistic literacy, disruption is disaster. Yet Aka's young people no longer follow their elders in learning the formal version of the language and the stories that have governed daily life. Even in this remote region, young people are seduced away from their mother tongue by Hindi on the television and English in the schools. Today Aka's speakers number fewer than 2,000,

# AKA

LANGUAGE

*India*

*Number of speakers*

1,000-2,000

[ tradzy ]

a necklace of yellow stone beads

*The Aka have more than 26 words to describe beads. Beyond being objects of adornment, beads are status symbols and currency. This toddler will get this necklace at her wedding.*

AKA

# [ shobotro vyew ]

to calculate bride price using twigs

*The price for an Aka marriage is negotiated with bamboo sticks. The groom's side lays down a number representing money and gifts, and the bride's family counteroffers. Families can haggle for months using the same sticks.*

AKA

# [ chofe gidego ]

## is looking at liver

*A marriage is not recognized until after the ritual slaughter of a mithan, a type of cattle, when its liver can be read. The verdict: A small spot might signal an accident in the couple's future but otherwise a happy life.*

AKA

# [ nichleu-nuggo ]

village counselor | wise, compassionate, tolerant

*Govardhan Nimasow is a rich man who married eight wives, fathered 26 children, and owns one of the few concrete houses in his village. But his status as a* nichleu-nuggo *also means he possesses humility and wisdom.*

few enough to put it on the endangered list.

One night in Palizi, Harrison, Anderson, an Indian linguist named Ganesh Murmu, and I sat cross-legged around the cooking fire at the home of Pario Nimasow, a 25-year-old teacher at the Jesuit school. A Palizi native, Nimasow loved his Aka culture even as he longed to join the outside world. In his sleeping room in an adjacent hut was a television waiting for the return of electricity, which had been out for many months thanks to a series of landslides and transformer malfunctions. After dinner Nimasow disappeared for a moment and came back with a soiled white cotton cloth, which he unfolded by the flickering light of the cooking fire. Inside was a small collection of ritual items: a tiger's jaw, a python's jaw, the sharp-toothed mandible of a river fish, a quartz crystal, and other objects of a shaman's sachet. This sachet had belonged to Nimasow's father until his death in 1991.

"My father was a priest," Nimasow said, "and his father was a priest." And now? I asked. Was he next in line? Nimasow stared at the talismans and shook his head. He had the kit, but he didn't know the chants; his father had died before passing them on. Without the words, there was no way to bring the artifacts' power to life.

LINGUISTICS HAS UNDERGONE two great revolutions in the past 60 years, on seemingly opposite ends of the discipline. In the late 1950s Noam Chomsky theorized that all languages were built on an underlying universal grammar embedded in human genes. A second shift in linguistics—an explosion of interest in small and threatened languages—has focused on the variety of linguistic experience. Field linguists like David Harrison are more interested in the idiosyncrasies that make each language unique and the ways that culture can influence a language's form. As Harrison points out, some 85 percent of languages have yet to be documented. Understanding them can only enrich our comprehension of what is universal to all languages.

Different languages highlight the varieties of human experience, revealing as mutable aspects of life that we tend to think of as settled and universal, such as our experience of time, number, or color. In Tuva, for example, the past is always spoken of as ahead of one, and the future is behind one's back. "We could never say, I'm looking forward to doing something," a Tuvan told me. Indeed, he might say, "I'm looking forward to the day before yesterday." It makes total sense if you think of it in a Tuvan sort of way: If the future were ahead of you, wouldn't it be in plain view?

Smaller languages often retain remnants of number systems that may predate the adoption of the modern world's base-ten counting system. The Pirahã, an Amazonian tribe, appear to have no words for any specific numbers at all but instead get by with relative words such as "few" and "many." The Pirahã's lack of numerical terms suggests that assigning numbers may be an invention of culture rather than an innate part of human cognition. The interpretation of color is similarly varied from language to language. What we think of as the natural spectrum of the rainbow is actually divided up differently in different tongues, with many languages having more or fewer color categories than their neighbors.

Language shapes human experience—our very cognition—as it goes about classifying the world to make sense of the circumstances at hand. Those classifications may be broad—Aka divides the animal kingdom into animals that are eaten and those that are not—or exceedingly fine-tuned. The Todzhu reindeer herders of southern Siberia have an elaborate vocabulary for reindeer; an *iyi düktüg myiys,* for example, is a castrated former stud in its fourth year.

If Aka, or any language, is supplanted by a new one that's bigger and more universally useful, its death shakes the foundations of the tribe. "Aka is our identity," a villager told me one day as we walked from Palizi down the path that wound past the rice fields to the forests by the river. "Without it, we are the general public." But should the rest of the world mourn too? The question would not be an easy one to frame in Aka, which seems to lack a single term for world. Aka might suggest an answer, though, one embodied in the concept of mucrow—a regard for

tradition, for long-standing knowledge, for what has come before, a conviction that the venerable and frail have something to teach the callow and the strong that they would be lost without.

SERI

## *THE WISDOM OF THE HANT IIHA CÖHACOMXOJ*

THE ONGOING collapse of the world's biodiversity is more than just an apt metaphor for the crisis of language extinction. The disappearance of a language deprives us of knowledge no less valuable than some future miracle drug that may be lost when a species goes extinct. Small languages, more than large ones, provide keys to unlock the secrets of nature, because their speakers tend to live in proximity to the animals and plants around them, and their talk reflects the distinctions they observe. When small communities abandon their languages and switch to English or Spanish, there is a massive disruption in the transfer of traditional knowledge across generations—about medicinal plants, food cultivation, irrigation techniques, navigation systems, seasonal calendars.

The Seri people of Mexico were traditionally seminomadic hunter-gatherers living in the western Sonoran Desert near the Gulf of California. Their survival was tied to the traits and behaviors of the species that live in the desert and the sea. An intimate relationship with the plant and animal worlds is a hallmark of the Seris' life and of their language, Cmiique Iitom.

Traditionally the Seris, who refer to themselves as the Comcaac, had no fixed settlements, so their locale of the moment depended on what part of the desert offered the most food, whether the cactus fruit was ripe on the mountainside or the eelgrass was ready to harvest in the bay. Today they reside in two settlements, Punta Chueca and El Desemboque, each a small covey of concrete-block homes set in the vast red, seemingly empty desert beside the gulf. The homes are surrounded by rows of thorny ocotillo canes stuck into the sand, where they've taken root as living fences.

Each day, Armando Torres Cubillas sits in the corner of his open-air, beachside atelier in El Desemboque, his crippled legs curled under him on the sandy ground, carving sea turtles from dark desert ironwood. Occasionally, if he's in the mood, he gazes out over the gulf and eases the artisanship with a song that relates the operatic story of a conversation between the small beach clam *taijitiquiixaz* and the mole crab. The verse is typical of songs of the Seri tribe: a celebration of nature, tinged with loss.

The Seris see their language as a defining characteristic, a seed of their identity. One Seri told me of a "local expression" that says everyone has a flower inside, and inside the flower is a word. A Seri elder, Efraín Estrella Romero, told me, "If one child is raised speaking Cmiique Iitom and another speaking Spanish, they will be different people."

When American linguists Edward Moser and Mary Beck Moser came to live with the Seris in 1951 in El Desemboque, the group's fortunes were at a low ebb—outbreaks of measles and influenza had reduced their numbers to a couple hundred. It was a propitious time for the researchers, though, because the group's culture hadn't yet been co-opted by the majority culture surrounding it. Mary Moser served the tribe as nurse and midwife. After many births, per custom, the families gave her a dried piece of their infants' umbilical cords, which Mary kept protected in a "belly button pot." They also gave her their long, eight-plait braids, markers of Indian identity that the men felt compelled to chop off when they traveled to Mexican towns. The braids were like cultural umbilical cords, severed connections between what was old and what was new, evidence of the broken link.

The Mosers had a daughter, Cathy, who grew up among the Seris in El Desemboque and became a graphic artist and ethnographer. She and her husband, Steve Marlett, a linguist with SIL International and the University of North Dakota, have continued the Mosers' study of the Seri language. Today the community has

*ıd inside the flower is a word. Language is a seed of Seri identity.*

rebounded to somewhere between 650 and 1,000 speakers. They have managed to hang on to their language, thanks in part to their hostility to the majority culture of Mexico. Steve Marlett diplomatically refers to this in one academic paper as "the general lack of cultural empathy between the Seri population and the Spanish-speaking population." In 1773 they killed a priest who tried to establish a mission. The Vatican did not send a follow-up, and the tribe was never Catholicized.

The Seris maintain to this day a proud suspicion of outsiders—and a disdain for unshared individual wealth. "When the Seris become rich, they will cease to exist" is a Seri saying. Having been nomadic, they tend to regard possessions as burdens. Traditionally, when a Seri died, he was buried with his few personal possessions. Nothing was passed down to relatives except stories, songs, legends, instructions.

What modern luxuries the Seris have adopted are imported without their Spanish names. Automobiles, for instance, have provoked a flurry of new words. A Seri car muffler is called *ihíisaxim an hant yaait,* or into which the breathing descends, and the Seri term for distributor cap associates it with an electric ray that swims in the Gulf of California and gives you a shock. Such words are like ocotillo canes stuck into the sand: The Cmiique Iitom lexicon is alive, and as it grows, it creates a living fence around the culture.

Sitting in the shade of an awning in front of his house, René Montaño told me stories of an ancient race of giants who could step over the sea from their home on Tiburon Island to the mainland in a single stride. He told me of *hant iiha cöhacomxoj,* those who have been told about Earth's possessions, all ancient things. "To be told" entails an injunction: Pass it on. Thanks to that, we have all become inheritors of the knowledge enshrined within Cmiique Iitom. Folk sayings and often even single words encase centuries of close observation of species that visiting scientists have only begun to study in recent decades.

Cmiique Iitom has terms for more than 300 desert plants, and its names for animals reveal behaviors that scientists once considered farfetched. The Seri word for harvesting eelgrass clued scientists in to the sea grass's nutritional merits. (Its protein content is about the same as wheat's.) The Seris call one sea turtle *moosni hant cooit,* or green turtle that descends, for its habit of hibernating on the floor of the sea, where the traditional fishermen used to harpoon it. "We were skeptical when we first learned from the Seri Indians of Sonora, Mexico, that some *Chelonia* are partially buried on the sea floor during the colder months," stated a 1976 paper in *Science* documenting the behavior. "However, the Seri have proved to be highly reliable informants." The Seris enjoyed eating sea turtles but not leatherbacks, for a simple reason. Leatherbacks, they say, understand their language and are Seri themselves. In 2005 the Seri name for shark, *hacat,* became the official name for a newly discovered species of smooth-hound shark, *Mustelus hacat.* Newly discovered by modern scientists, that is—the Seris had been aware of them for years.

The Seri language is what linguists call an isolate, though a better term might be "sole survivor." "The Seris are a window into a lost world of gulf peoples," Steve Marlett says, referring to the extensive family of potentially linguistically linked groups who once inhabited both coasts of the Gulf of California. "Many others are gone," he says, and worse, gone before they could be documented. One remaining key to the nearly vanished cultures is Cmiique Iitom.

ONE WAY TO PRESERVE a language is to enshrine it in writing and compile a dictionary. Linguists both love and fear the prospect of inventing scripts for languages that are usually verbal only. Fear because the very idea of an alphabet changes the language the alphabet *(Continued on page 86)*

# SERI

LANGUAGE

*Mexico*

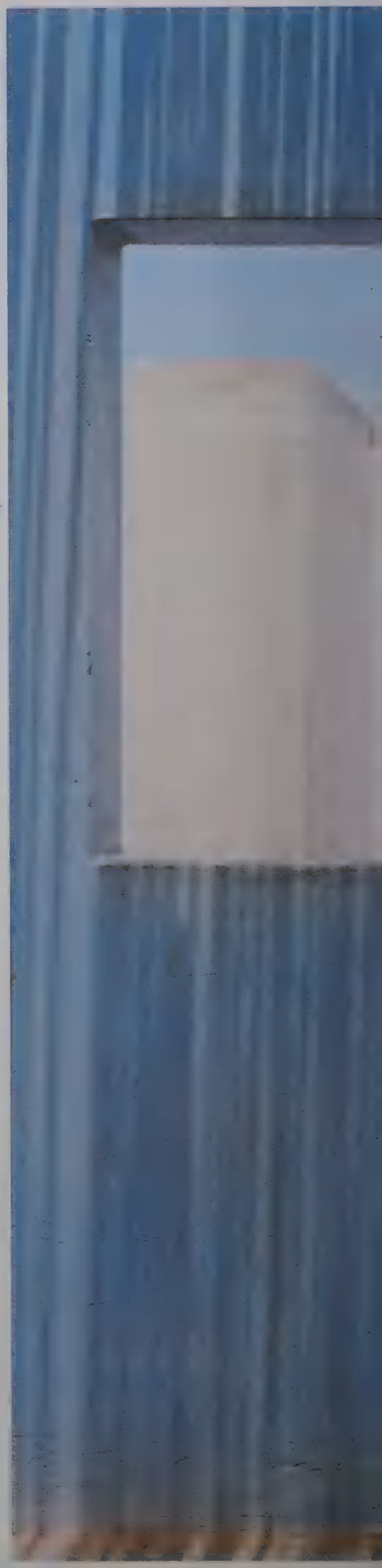
*Number of speakers*

650-1,000

[ ziix quih haasax
haaptxö quih
áno cöcacaaixaj ]

one who strongly greets
with joy/peace/harmony

*There is no greeting among the Seris akin to a handshake or wave. But Josué Robles Barnett demonstrates a gesture that used to be performed when arriving in a strange community to convey you meant no harm.*



SERI

# [ hant iiha cöhacomxoj ]

## ones who have been told the ancient things

*She's blind and nearly deaf, but Isabel Chavela Torres still passes on traditional knowledge. The Seri names for species in the Sonoran Desert and Gulf of California reveal behaviors scientists have only recently begun to discover.*

SERI

# [ hepem cöicooit ]

one who dances like the white-tailed deer

*Chavela's grandson Jorge Luis Montaño Herrera shakes gourd rattles and assumes the identity of a deer. Just as his grandmother once sang him traditional melodies, he now wants to teach the deer dance to Seri children.*

SERI

# [ ziix hacx tiij catax ]

## thing that moves on its own

*As modern inventions like cars enter their world, the Seris tend to adapt their language rather than import Spanish words. Erica Barnett uses an abandoned car as a hothouse to grow mangroves to replenish an estuary.*

SERI

[ atcz | azaac ]

daughter of a parent's younger sibling | daughter of a parent's older sibling

*The Seris have more than 50 terms for kinship relationships, such as between these two cousins, many specific to the gender and birth order of the relative. A woman uses a different word for father than a man does.*

is meant to preserve and converts the linguist from observer to activist. David Harrison and Greg Anderson compiled the first Tuvan-English dictionary and are proud of the excitement the volume elicited from native speakers. Steve and Cathy Marlett worked until 2005 finishing a Cmiique Iitom dictionary begun by her parents in 1951. Steve remembers the day René Montaño asked, "Can I show you how I write?" and demonstrated a way of dividing words that had not occurred to the linguist before. The revelation meant revising years of work. But Marlett was delighted, because the project was enlisting native Seri speakers into diagnosing and defining their own language.

The cataloging of vocabulary and pronunciation and syntax that field linguists do in remote outposts helps keep a language alive. But saving a language is not something linguists can accomplish, because salvation must come from within. The answer may lie in something Harrison and Anderson witnessed in Palizi one day, when a villager in his early 20s came with a friend to perform a song for them. Palizi is far removed from pervasive U.S. culture, so it was something of a surprise to the two linguists when the teenagers launched into a full-bore, L.A.-style rap song complete with gang hand gestures and head bobbing and attitude, a pitch-perfect rendition of an American street art, with one refinement: They were rapping in Aka.

Were the linguists dismayed? I asked. To the contrary, Harrison said. "These kids were fluent in Hindi and English, but they chose to rap in a language they share with only a couple thousand people." Linguistic co-optation and absorption can work both ways, with the small language sometimes acting as the imperialist. "The one thing that's necessary for the revival of a language," Father D'Souza told me one day, "is pride."

Against the erosion of language stands an ineffable quality that can't be instilled from without: someone's insistence on rapping in Aka, on singing in Tuvan, on writing in the recently orthographized Cmiique Iitom. The Mosers' and Marletts' dictionary initiative has given birth to a new profession in Seriland: scribe. Several booklets have been authored by Seris. The Marletts hope the number of volumes will reach 40, one threshold, it is believed, for enticing people to maintain literacy in a language (though some put the number much higher).

The interest is already there. The Marletts had a regular visitor when they were living in El Desemboque, a young boy who would come each day to pore over a Cmiique Iitom booklet. One day he arrived, and the Marletts explained they'd lent it to someone else. "He just burst into uncontrollable tears," Steve remembers.

The spread of global culture is unstoppable. Kyzyl, a capital city that never had a railroad connect it to the rest of Russia, will get one in the next few years. In El Desemboque power lines have been run through the desert to drive an electric pump for a municipal well. And in Arunachal Pradesh a new hydroelectric dam has been completed, ensuring the village of Palizi better access to electricity, refrigeration, and television.

To be involved in the plight of vanishing languages, even just as a journalist, is to contemplate the fragility of tribal life. Since my visits over the past two years to Palizi and Kyzyl and Seriland, Efraín Estrella died of pancreatitis, and young Pario Nimasow, who unwrapped his father's shaman's kit for me and wondered what its contents might mean, was killed in a landslide. A week after I wrote the paragraph describing Armando Torres's daily singing, I received an email from Cathy Marlett. "Sad news," its subject line read. Torres had died of a heart attack at 67, in his place by the beach in El Desemboque.

Their mortality is a reminder of the mortality of their cultures, an intimation that with each speaker's death another vital artery has been severed. Against that—against the possibility that their language could slip away without alarm or notice—stands a proud perseverance, a reverence for the old, an awareness that in important ways a key to our future lies behind us. That, and an insistence that the tongues least spoken still have much to say. □

**The Enduring Voices Project** is funded in part by your National Geographic Society membership.

SERI

# [ Miixöni quih zó hant ano tiij? ]

Where is your placenta buried?

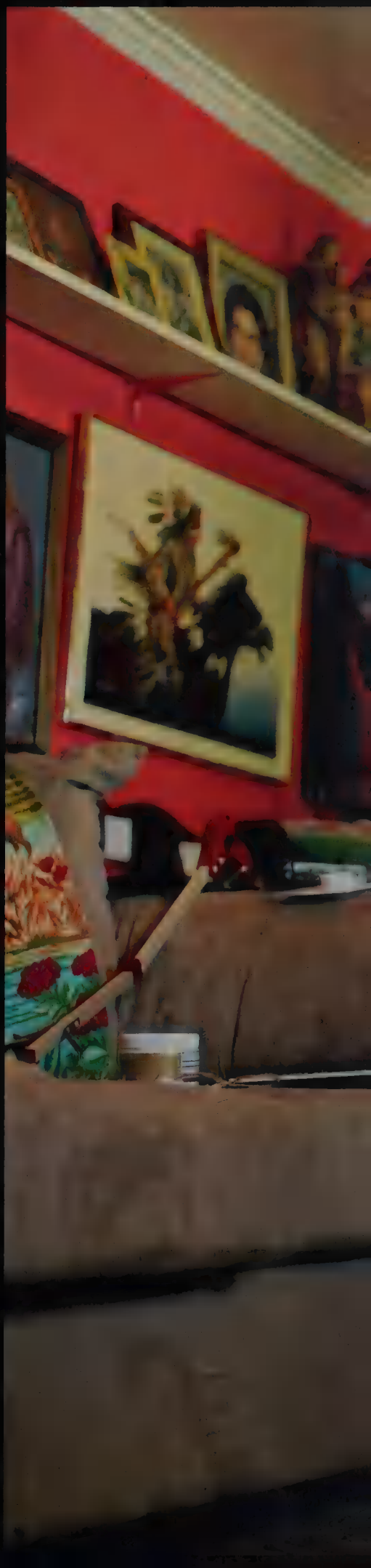
*This is how the Seris ask, Where are you from?*
*Those who were born before hospital births*
*know the exact spot where their afterbirth was*
*placed in the ground, covered in sand*
*and ash, and topped with rocks.*

# EUCHEE

LANGUAGE

*Oklahoma*

*KasA Henry Washburn, 86, is one of only four fluent speakers of Euchee left. Every day he drives ten miles from his home in West Tulsa to the Euchee Language House, where children are learning their native tongue. As a result, Euchee students sometimes get in trouble again for speaking their ancestral language in school. Richard Grounds, director of the project that is recording Washburn's memories, calls him a "living dictionary."*



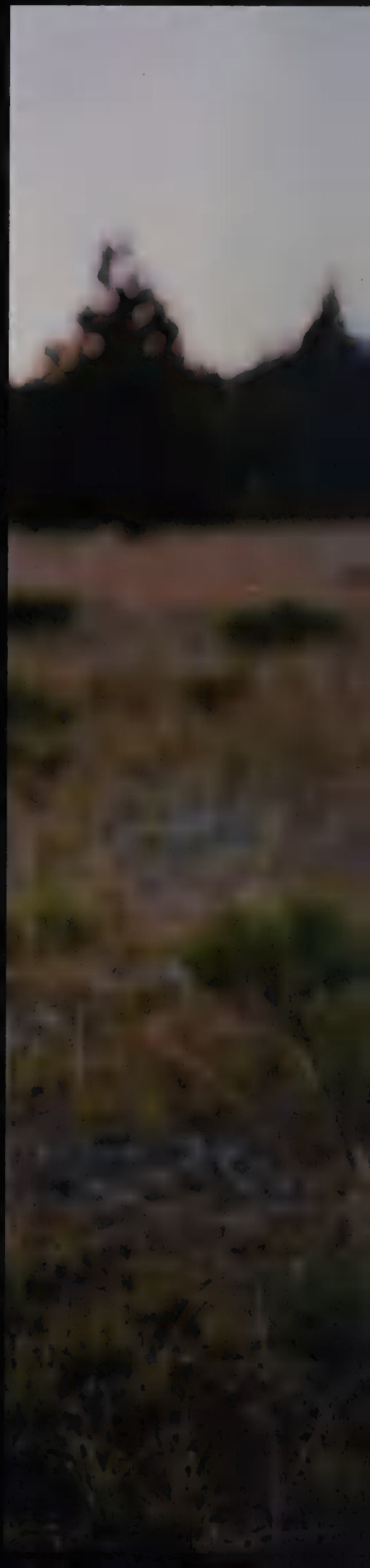
iPad Exclusive: Listen to the voices of last speakers of endangered languages in a special portrait gallery

# WINTU

LANGUAGE

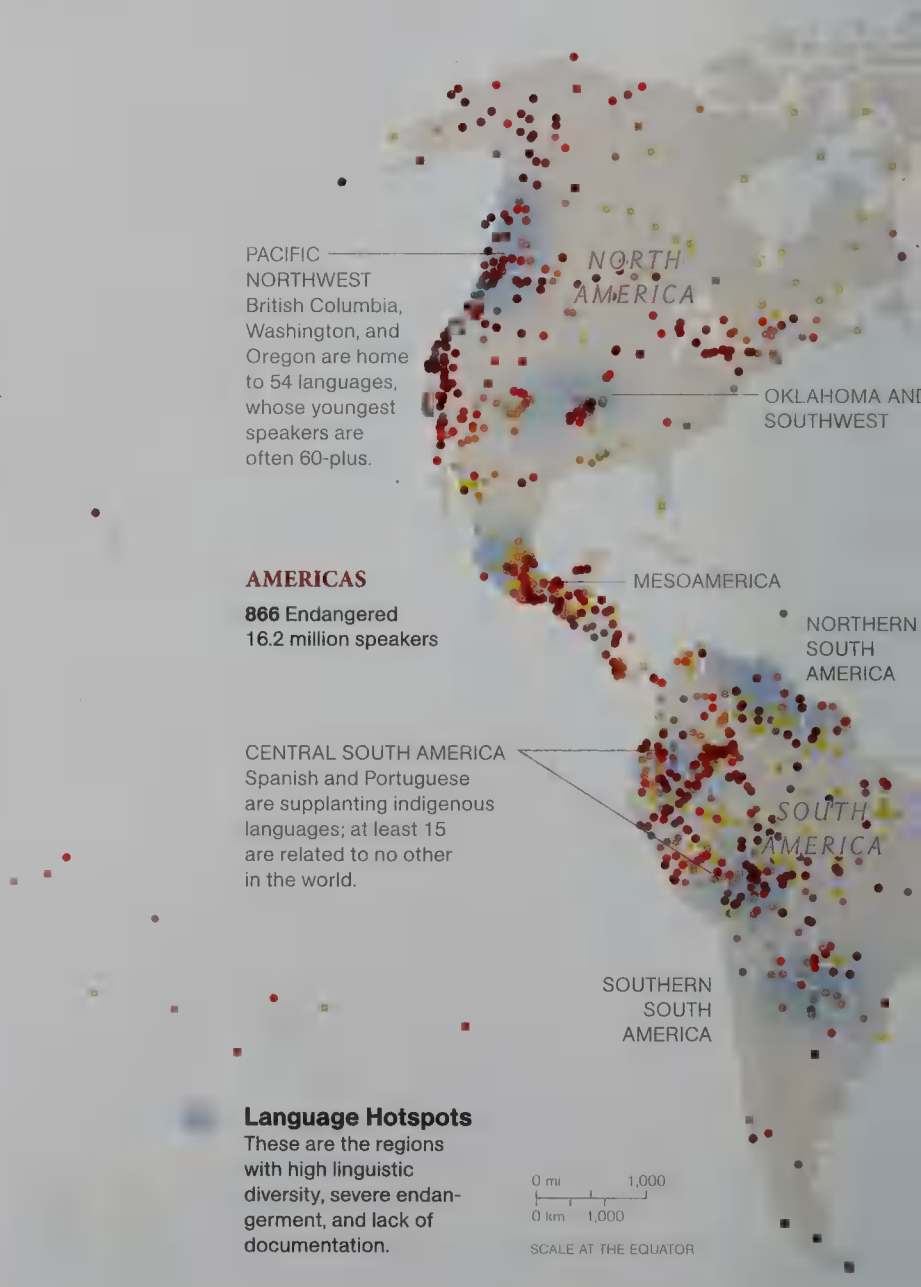
*California*

*Caleen Sisk is the spiritual leader and tribal chief of the Winnemem Wintu tribe—and a last speaker of the language that sustains her people's identity. For more than a hundred years tribal members have been fighting with the U.S. government over their territory along the McCloud River, abutting Mount Shasta, which they consider their birthplace. Loss of land and loss of language are connected, says Sisk. "This land is our church."*



# LANGUAGES AT RISK

Language follows power. In an increasingly globalized and homogenized era, languages that dominate world communication and commerce jump geopolitical borders and geographical boundaries, pushing smaller languages toward extinction. Linguists have identified hotspots where revitalization efforts could be targeted, before many native tongues fade away forever.


PACIFIC NORTHWEST
British Columbia, Washington, and Oregon are home to 54 languages, whose youngest speakers are often 60-plus.
NORTH AMERICA
OKLAHOMA AND SOUTHWEST
AMERICAS
866 Endangered
16.2 million speakers
MESOAMERICA
NORTHERN SOUTH AMERICA
CENTRAL SOUTH AMERICA
Spanish and Portuguese are supplanting indigenous languages; at least 15 are related to no other in the world.
SOUTH AMERICA
SOUTHERN SOUTH AMERICA
Language Hotspots
These are the regions with high linguistic diversity, severe endangerment, and lack of documentation.
0 mi 1,000
0 km 1,000
SCALE AT THE EQUATOR

## Threat Level

UNESCO ranks the world's languages by degree of intergenerational usage: 2,724 are endangered or extinct.

- **Critical: 607**
  Spoken rarely and only by older generations
- **Severe: 554**
  Spoken only by older generations
- **Definite: 681**
  Replaced as mother tongue by new language
- **Vulnerable: 628**
  Spoken by children but rarely outside the home
- **Extinct: 254 languages**
  No speakers since 1950

## Dominant Languages

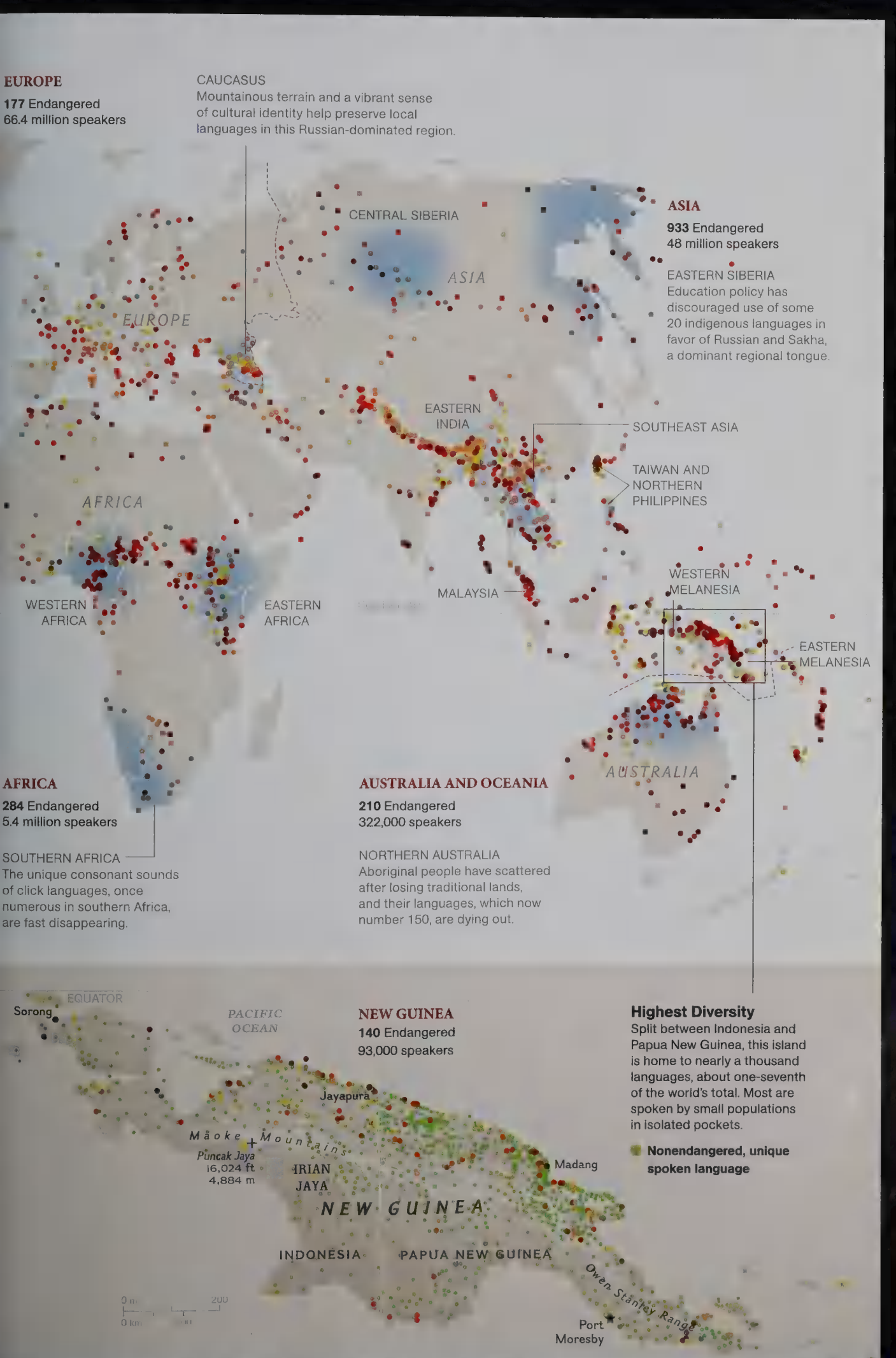
Nearly half of the world speaks a top-ten language. The smallest 3,524 languages, spoken by fewer than 10,000 people each, are used by just 0.1 percent of the world's population.

**First-Language Speakers** (in millions)

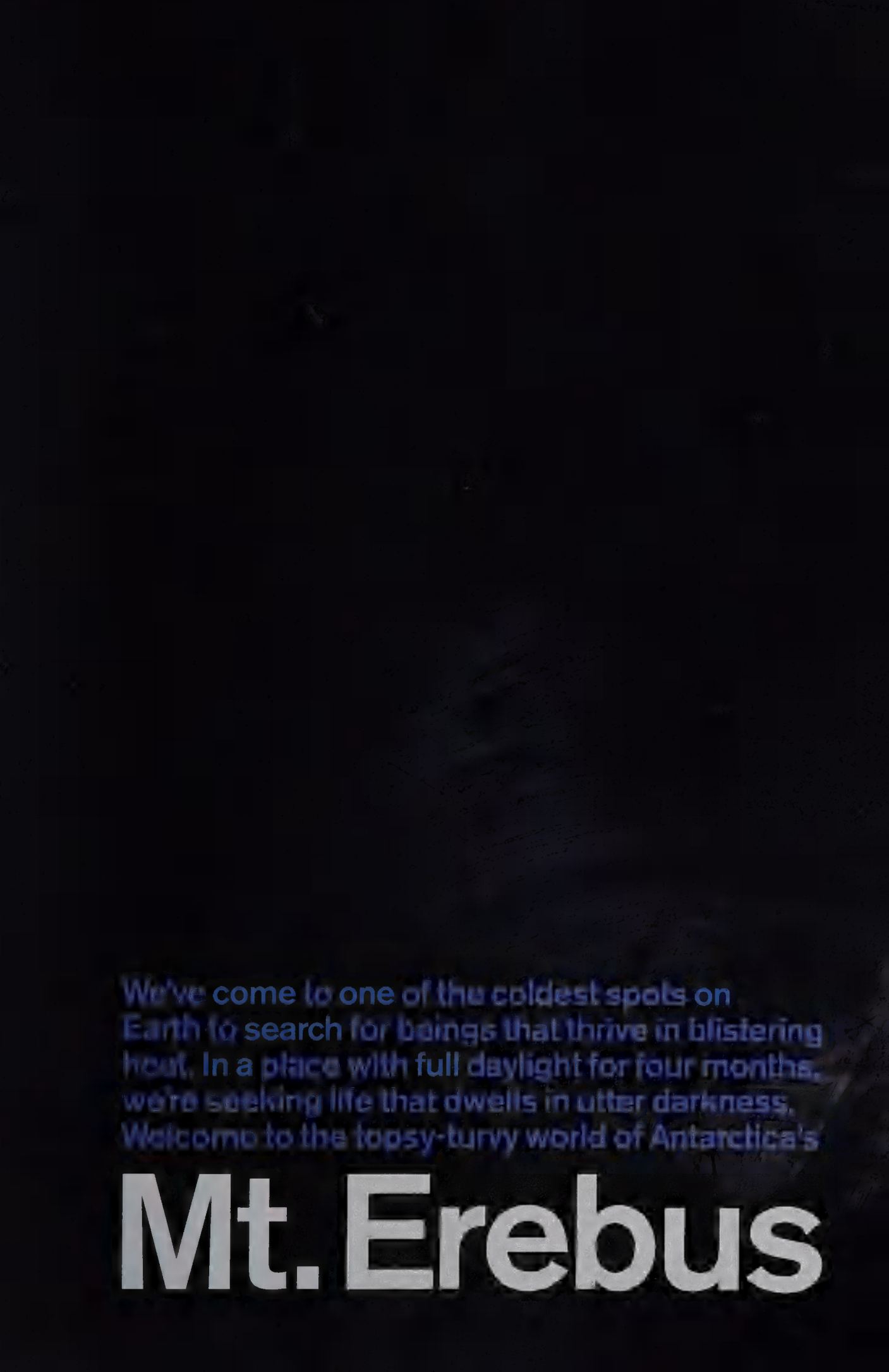
| | |
|---|---|
| German | 90 |
| Japanese | 122 |
| Russian | 144 |
| Portuguese | 178 |
| Bengali | 181 |
| Hindi | 182 |
| Arabic* | 221 |
| English | 310 |
| Spanish | 329 |
| Chinese* | 1,213 |

*INCLUDES ALL FORMS OF THE LANGUAGE

VIRGINIA W. MASON, NGM STAFF; MARTY SCHNURE
SOURCES: LIVING TONGUES INSTITUTE FOR ENDANGERED LANGUAGES; UNESCO; SIL INTERNATIONAL

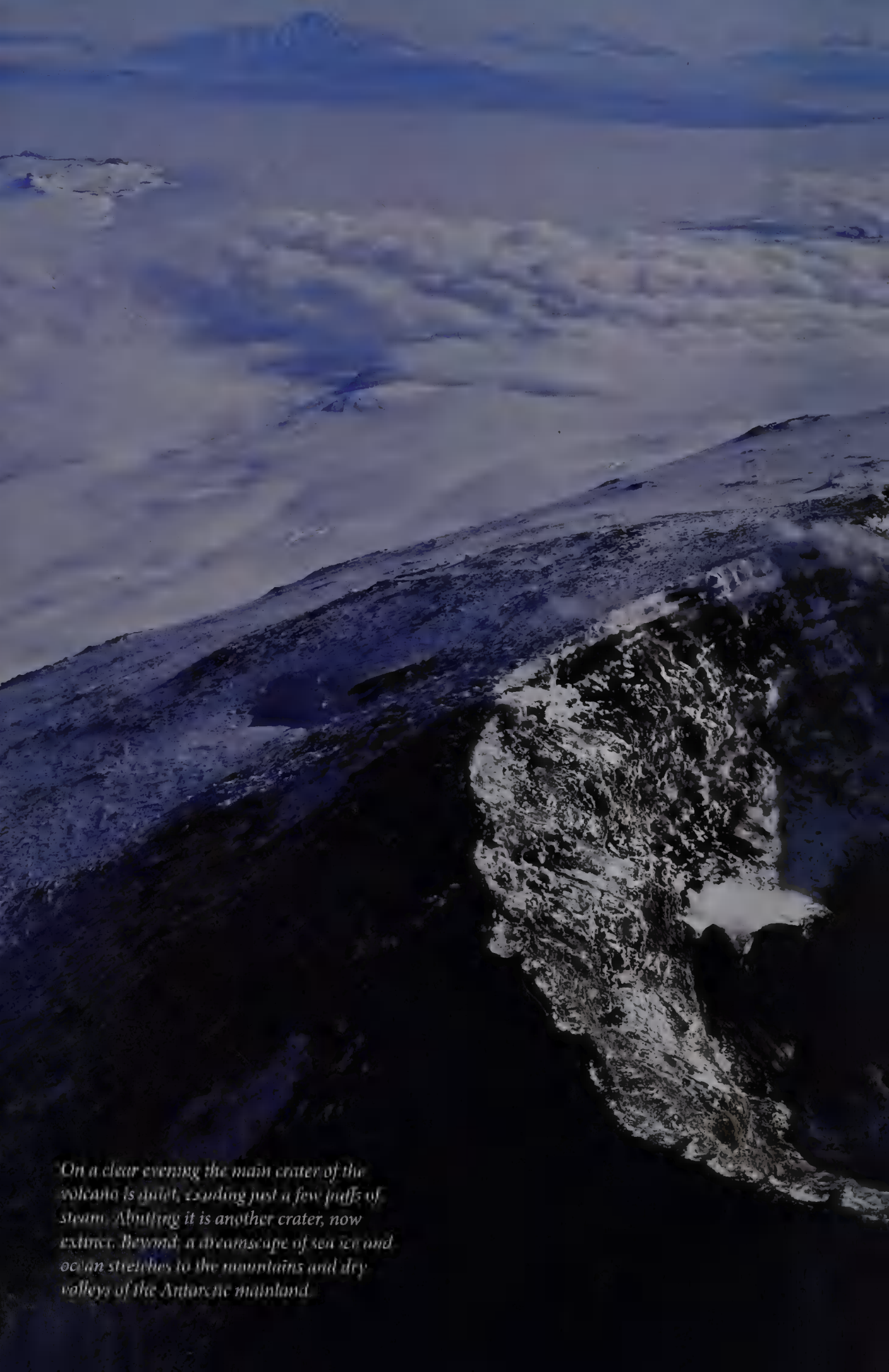

EUROPE
177 Endangered
66.4 million speakers
CAUCASUS
Mountainous terrain and a vibrant sense of cultural identity help preserve local languages in this Russian-dominated region.
CENTRAL SIBERIA
ASIA
EUROPE
ASIA
933 Endangered
48 million speakers
EASTERN SIBERIA
Education policy has discouraged use of some 20 indigenous languages in favor of Russian and Sakha, a dominant regional tongue.
EASTERN INDIA
SOUTHEAST ASIA
TAIWAN AND NORTHERN PHILIPPINES
AFRICA
WESTERN AFRICA
EASTERN AFRICA
MALAYSIA
WESTERN MELANESIA
EASTERN MELANESIA
AUSTRALIA
AFRICA
284 Endangered
5.4 million speakers
SOUTHERN AFRICA
The unique consonant sounds of click languages, once numerous in southern Africa, are fast disappearing.
AUSTRALIA AND OCEANIA
210 Endangered
322,000 speakers
NORTHERN AUSTRALIA
Aboriginal people have scattered after losing traditional lands, and their languages, which now number 150, are dying out.
EQUATOR
Sorong
PACIFIC OCEAN
NEW GUINEA
140 Endangered
93,000 speakers
Jayapura
Mäoke Mountains
Puncak Jaya
16,024 ft
4,884 m
IRIAN JAYA
Madang
NEW GUINEA
INDONESIA
PAPUA NEW GUINEA
Owen Stanley Range
Port Moresby
0 mi
200
0 km
Highest Diversity
Split between Indonesia and Papua New Guinea, this island is home to nearly a thousand languages, about one-seventh of the world's total. Most are spoken by small populations in isolated pockets.
Nonendangered, unique spoken language

*Sunlight filters through the dome of an ice cave on Erebus, the most southerly active volcano in the world.*


We've come to one of the coldest spots on
Earth to search for beings that thrive in blistering
heat. In a place with full daylight for four months,
we're seeking life that dwells in utter darkness.
Welcome to the topsy-turvy world of Antarctica's
Mt. Erebus

*A study in contrasts: ice and snow in the foreground, the lava lake of Mount Erebus below. Erebus is one of just a handful of volcanoes to boast a permanent lava lake. At the moment this picture was taken, the volcano was quiet, but it frequently erupts, hurling lava bombs high in the air.*

*A web of ropes and ladders eases access to Warren Cave, a labyrinth of passages melted from the ice by the caldron's heat. Small currents of air probably cause the scalloping around the cave's entrance.*



*On a clear evening the main crater of the volcano is quiet, exuding just a few puffs of steam. Abutting it is another crater, now extinct. Beyond, a dreamscape of sea ice and ocean stretches to the mountains and dry valleys of the Antarctic mainland.*

*By Olivia Judson*
*Photographs by Carsten Peter*

The scene: a tent on Mount Erebus, an active volcano on Ross Island, Antarctica. The tent is a four-cornered tepee modeled after those that Captain Robert Falcon Scott brought with him on his Antarctic expeditions more than a century ago. It is high enough at the center for someone five feet five inches tall to stand erect and has two vents at the peak that serve as chimneys. This particular tent is occupied by two people; both are in sleeping bags. Between the sleeping bags are a large box, a Primus stove, a couple of thermoses, and two pairs of heavy boots. It is too cold to read; even with gloves on, it is too cold to hold a book. Thus the inmates—of whom I am one—are passing the time by talking.

"What are your favorite microbes?" I say, dusting ice off my sleeping bag.

"It's got to be those funky archaea," says my companion, Craig Herbold, a large, thirty-something American with a taste for Japanese electronic music and an interest in astrobiology, the study of what life elsewhere in the universe might be like. He's a postdoctoral researcher at the University of Waikato in New Zealand and the junior member of a team of three who have come here to look for life in the volcano's hot soils. That's right. He's come to one of the coldest places on Earth to look for beings that thrive in heat.

Mount Erebus is the most southerly active volcano on the planet. It began to form about 1.3 million years ago and now stands 12,448 feet above sea level. Its slopes are covered with snow and ice, glaciers, crevasses, and the occasional lava flow, but steam usually rises from its summit, betraying the heat within. If Erebus were a dessert, it would be a reverse baked Alaska—frozen on the outside, hot in the middle.

It was discovered in 1841 during an expedition led by Sir James Clark Ross, who named it after one of his ships, the H.M.S. *Erebus,* which had in turn been named after the Greek god of primeval darkness. (Ross's other ship, the H.M.S. *Terror,* gave its name to a smaller, extinct volcano that stands next to Erebus.) But no one reached the summit until 1908, when the mountain was climbed by members of Sir Ernest Shackleton's Nimrod expedition—the expedition on which Shackleton led a team to within a hundred nautical miles of the South Pole but turned back so as to get everyone home alive.

Shackleton's party hiked up Erebus. It took them five and a half days to get to the top, an undertaking that included a blizzard that kept them in their sleeping bags for more than 24 hours with nothing to drink, exposed them to temperatures of minus 30°F, caused one man to collapse with exhaustion, and gave another such an extreme case of frostbite that he ultimately lost a big toe.

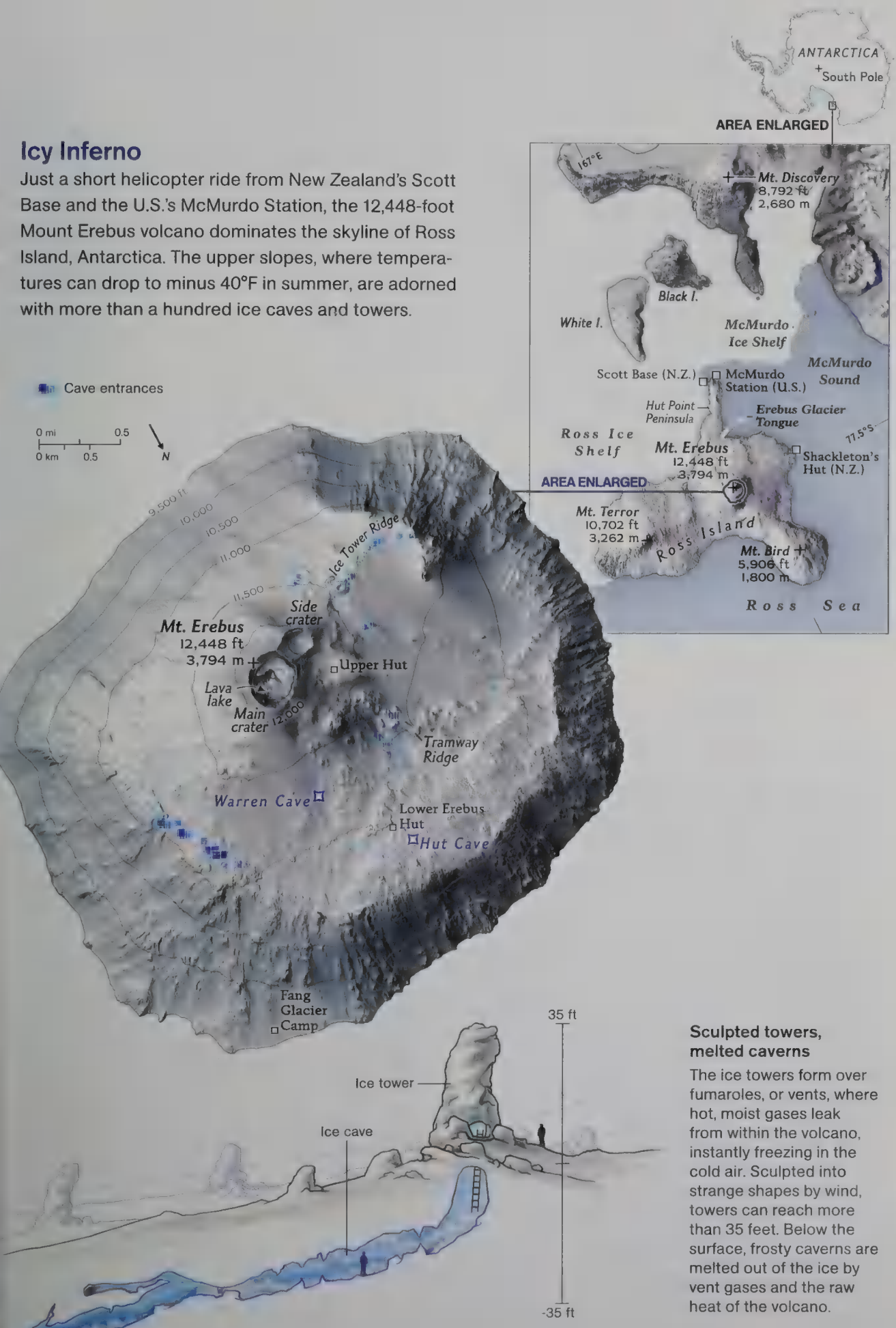
Our journey was less arduous: We went by helicopter.

WE WERE EIGHT. There were the aforementioned Herbold and the two senior members of his research team: Craig Cary, a flamboyant American, and Ian McDonald, an understated

*Olivia Judson is the author of* Dr. Tatiana's Sex Advice to All Creation. *This is her first story for* National Geographic. *Carsten Peter's last story was on Australian slot canyons, in October 2011.*

## Icy Inferno

Just a short helicopter ride from New Zealand's Scott Base and the U.S.'s McMurdo Station, the 12,448-foot Mount Erebus volcano dominates the skyline of Ross Island, Antarctica. The upper slopes, where temperatures can drop to minus 40°F in summer, are adorned with more than a hundred ice caves and towers.




### Sculpted towers, melted caverns

The ice towers form over fumaroles, or vents, where hot, moist gases leak from within the volcano, instantly freezing in the cold air. Sculpted into strange shapes by wind, towers can reach more than 35 feet. Below the surface, frosty caverns are melted out of the ice by vent gases and the raw heat of the volcano.

MARTIN GAMACHE AND MATTHEW TWOMBLY, NGM STAFF

SOURCES: BRITISH ANTARCTIC SURVEY; BEA CSATHO, UNIVERSITY AT BUFFALO; AARON CURTIS, NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY; NASA; NATIONAL SCIENCE FOUNDATION U.S. ANTARCTIC PROGRAM

Englishman, both biologists at the University of Waikato, both veterans of Antarctic research. Cary also has an appointment at the University of Delaware, and before he began working in Antarctica, he traveled regularly to the bottom of the sea to study organisms that live on deep-sea vents. Stu Arnold and Al Moore, two wind-burned New Zealanders with broad shoulders and broader accents, had the job of keeping us from, in Arnold's words, "getting carnaged by the mountain." Then there were Carsten Peter, the photographer, and his assistant, Daniel Jehle, both from the mountains of southern Germany. And then there was me: in Jehle's words, "a girl."

Despite its remote location and savage climate—the temperature averages minus 4°F in the summer and minus 58°F in winter—Erebus

**If you don't eat your food within a few minutes, it will freeze. I had to chip my cereal out of the bowl.**

is a much studied volcano. Since 1972 a team of volcanologists, long led by Philip Kyle, a professor of geochemistry at the New Mexico Institute of Mining and Technology, has spent part of each austral summer on the mountain investigating matters such as the nature and frequency of its eruptions, the types of gases it gives off, and the age of its rocks.

The biology of the place has been less well documented. This is in part because up on Erebus most life-forms are microscopic. (The main exceptions are a few mosses and cyanobacteria—bacteria that, like plants, turn sunlight into energy and that can grow into colonies large enough for us to see.) Until recently the study of unknown microbes has been problematic: If you couldn't grow it in the laboratory, you couldn't describe it, let alone study it. And most microbes don't take to laboratory life.

But it's no longer necessary to grow a microbe to know something about it. In the past decade or so, genetic techniques have been developed that allow whole communities of microbes to be characterized by their DNA alone, giving us a far more complete picture of what lives where. So although life had been found in the hot soils of Erebus in the early 1960s, it's only now that we're able to do much in the way of studying it.

The hot soils of Erebus are dotted around its summit, most famously at a site called Tramway Ridge. Heat from the volcano melts the ice, creating small patches of hot, moist soil that become home to communities of mosses and microbes.

But here's the thing. These patches are tiny islands of warmth in a sea of coldness. Although the soils themselves are hot—they can reach temperatures of 149°F—the air just above is not. Moreover, move a couple of feet away from the hot spot, and the soil temperature drops sharply. The acidity changes too. At the hot spot the soil is relatively neutral; a short distance away it's harshly acidic. And lifeless: Cold, dry, and acid is unfriendly to life.

The presence of these islands raises intriguing questions. Which microbes live there, and where did they come from? Microbes can travel hundreds of miles on the wind. Did these blow in from the hot soils of volcanoes farther north? Or are the microbes on Erebus unique, and—this would be tremendously exciting—are they beings that have come up from deep within the Earth? The deep subsurface biosphere, where these organisms live in rocks far below the surface of the Earth, is one of the planet's least known ecosystems. But it may be one of the largest—some estimates suggest that one-third of all bacteria on the planet might live there—and weirdest. Such microbes don't make their living by drawing energy from the sun. Instead, they get energy from other sources, such as iron or hydrogen. This deep, dark ecosystem might also be among the Earth's most primeval and

could be home to life-forms that have long been charting a separate evolutionary course.

With such matters in mind, we set off.

OUR TRIP BEGAN in the offices of Antarctica New Zealand, in Christchurch, where a jolly man called Chris issued us clothes: long underwear, two pairs of fleece trousers (thick and thin), two fleece jackets (ditto), a pair of windproof overalls, a light jacket of synthetic down, a windbreaker, a heavy jacket of real down, two pairs of boots, two pairs of thick socks, down tent slippers, nine pairs of gloves and mittens, a hat, a balaclava, a neck gaiter (a scarf shaped like a tube), snow goggles, and sunglasses. Because Antarctica is a desert, albeit a chilly one, Chris also gave each of us a widemouthed water bottle emblazoned with the command HYDRATE OR DIE! along with a list of the more common signs of dehydration.

Thus outfitted, we flew on a U.S. military transport plane—along with a few other passengers and some huge crates labeled "Do not freeze"—to Ross Island. We landed on an expanse of sea ice and stepped out into a landscape of white, blue, and gold. White: ice, snow, clouds. Blue: sky, certain kinds of ice, and where you can see it, open ocean. Gold: reflections of the sun off ice or clouds. But we didn't have long to take it in, because we were met by a man wearing a gigantic bobbled hat and driven the short distance to Scott Base, New Zealand's research station in Antarctica, for training.

Even in these modern times, when if something goes wrong there's a reasonable chance of rescue, the practicalities of Antarctic travel are detailed and complex. "Make no assumptions,"

*The microbiology team gets ready to sample the volcano's hot soils. To protect the resident life-forms from invasive ones, the researchers spray their boots with ethanol to remove any contaminants and wear sterile suits over their cold-weather gear—giving them the look of monstrous snowmen.*

*It's midnight, but with the light so bright, it's hard to stop exploring the ice towers. This is one of the biggest on Erebus, but the flux of heat and moisture from below has collapsed its side. In the distance, beyond another ice tower, the Hut Point Peninsula extends like a finger toward Mount Discovery.*

*Inside the caves the volcano's warm, wet air freezes into frost crystals that grow into different shapes, depending on how the air currents flow. Here, a team member explores the passages of Hut Cave. At left, light filters greenly through a vent encrusted with frost crystals in Warren Cave.*

Explore the crystal caves of Hut Cave in the iPad edition.

said Arnold on the first day of our training. "Check all your equipment."

McDonald leaned over to me and said, "Be sure to check that your thermos works—that it keeps water hot overnight and doesn't leak."

"Do you still have the water bottle we bought in New Zealand?" said Cary. I nodded. "Take it with you. It's easier to drink from when you're lying in the sleeping bag. If you drink from the one you were issued, you could pour water all over yourself—and oh boy, then you're in trouble."

Trouble, because wet means cold. At best, wet clothes and sleeping bags wick warmth away from your skin. At worst, they freeze into a suit of ice. One of the early explorers described how he left his tent in clothes merely damp from sweat and the humidity of his own breathing: "Once outside, I raised my head to look round and found I could not move it back. My clothing had frozen hard as I stood—perhaps fifteen seconds." Yikes.

And so we tested thermoses and water bottles. We went on excursions to try out the clothes—different combinations suit different people—and went shopping at nearby McMurdo Station, the American base, for snowmobile masks. Also at McMurdo, a tattooed motorbike enthusiast called Toby taught us to "he-man" snowmobiles and explained how to change the spark plugs. Back at Scott Base we assembled sleeping kits. On the bottom a foam mat. Next an inflatable air mattress. On top of this a sheepskin rug. "Because we're Kiwis and we like sheep," said Arnold. Finally two down sleeping bags, one inside the other plus a polar fleece liner, inserted into a protective covering. All this done, we weighed everything, including ourselves, because helicopters are easy to overload.

Then we waited. The evening we were due to fly up the mountain, a big cloud was sitting on top of it. It wasn't until late the next afternoon that the weather cleared enough for us to go.

FIRST STOP, Fang Glacier Camp, a site on the side of the volcano about 9,850 feet above sea level, where we were to spend several days letting our bodies get used to the altitude. Fang sits on a snowfield at the top of a glacier with a view of the mountains of the Antarctic continent on one side and of the snow-clad summit of Mount Terror on the other. The dark fang of rock for which the camp is named juts into the sky in front; it's the remnant of a caldera that collapsed hundreds of thousands of years ago. When the wind drops, the silence is total. No engines, birds, insects; no rustling leaves. Also, at this time of year the sun doesn't set, and the light is bright—ski-slope bright—all the time. The only difference between noon and midnight is that at midnight the shadows are longer and the air is colder.

But Fang Camp is just that, a camp. Whereas our eventual base of operations, Lower Erebus

*Stu Arnold of the research support agency Antarctica New Zealand steadies a drill bit, while microbiologist Craig Cary drives it into an ice-tower wall. Moments later, cries of delight: They have a perfect ice core. They hope it will contain microbes lofted from deep within the volcano and frozen in the tower ice.*

Hut, has two small buildings (the eponymous hut and a shed) with electricity, heat, chairs, tables, and a stove with an oven, Fang consists of nothing but a row of tents pitched on snow.

Camping in this environment presents certain difficulties. For example, if you don't eat your food within a few minutes of its being cooked, it will freeze. One morning I didn't eat my cereal fast enough—and had to chip it out of the bowl. The only way to keep something warm is to heat it with your own body heat. This means you must keep it with you in your sleeping bag. Which is how I came to share my sleeping bag with lip balm, moisturizer, toothpaste, baby wipes, a camera, a watch, several pens, one pair of tent slippers, two pairs of gloves, two water bottles, three batteries, and three pee bottles.

Pee bottles? To acclimate to altitude you must drink one and a half to two gallons of liquid a day, all of which, incidentally, has to be made by melting snow. Drinking so much has obvious consequences. So at Fang there is a toilet tent. However, to go to the toilet tent you must

get completely dressed; when it's 40 below outside, you don't sally forth in pajamas. For convenience, therefore, you stay in your tent and pee into bottles. When these are full, you go to the toilet tent and empty them. If they freeze—you're stuck.

Meanwhile, there's nothing to do at Fang but talk to your tentmate and melt snow. And so it was that Herbold and I came to be discussing the funky archaea.

"They're so strange," Herbold says. "I just can't figure them out."

Archaea are one of the three main branches, or domains, of the tree of life. (The others are bacteria, and eukaryotes—organisms with nuclei in their cells, like plants, fungi, and animals.) And although archaea can and do live in mundane places such as the open ocean, they are also celebrated for being extremophiles—lifeforms that thrive in the most extreme environments this planet has to offer. Such as boiling acid—that sort of thing. So it's not surprising that they should be lurking in the hot soils of Mount Erebus.

**Are the microbes on Erebus unique, and did they come up from deep within the Earth?**

But these archaea are particularly mysterious. Found in soils that the group collected on previous trips to Erebus, so far they're known only from their DNA sequences, which bear little resemblance to those of archaea that have been discovered elsewhere. This suggests, perhaps, that they have indeed long been charting their own evolutionary course. Are they from the deep subsurface? It's too soon to tell.

"We found them on Tramway, right underneath the cyanobacterial mats," Herbold says. "But we don't know anything about their lifestyle." He pauses, then adds, "The cyanobacterial mats are creepy. They look like matted hair that's been splattered on the ground and partially digested."

As we talk, the wind begins to pick up. Soon it's too loud to hear each other. For the next 15 hours the wind hurls ice crystals at the tent and makes the walls rattle and flap. The only thing to do is lie huddled in the sleeping bag, listening.

It's a relief when two days later we are deemed acclimated, the skies are clear, and a helicopter thuds into view.

THE FLIGHT FROM FANG to Lower Erebus Hut is brief. But you arrive in a different landscape. Above, the crater of Erebus, steaming gently. Two buildings, the hut and the shed. An array of solar panels. And a row of fantastically shaped ice towers. The largest looks like an astronaut, and the others look as if they're following in procession. I'm not alone in seeing figures in the ice towers. Shackleton's men took a photograph of themselves with one that they thought resembled a lion. And as they surmised, the ice towers mark the sites of fumaroles—vents where the volcano releases hot, moist gases. When the moisture hits the cold air, it freezes, building structures that can be more than 35 feet tall.

Lower Erebus Hut is simple—one room plus an antechamber for frozen food—but compared with Fang, it's a luxury hotel. Here's a typical evening. Above the heater, a row of gloves drying. Herbold is in one corner, sterilizing equipment to take into the field the next day. McDonald is bringing in a vat of snow to make more water. Cary is talking about how Erebus is part of a larger study of volcanic hot soils: They already have soils from other Antarctic volcanoes, they went to Yellowstone last summer, and they plan to go to Costa Rica soon. Jehle is cooking. Peter is worrying about his cameras. Arnold is making a radio call to Scott Base. Moore is outside fixing one of the snowmobiles. And I'm washing up and thinking about the immensity of the landscape.

THE ACTUAL DOING of scientific fieldwork is often humdrum. But on Erebus the humdrum takes you to astounding places. Let me paint three scenes.

One, we're wearing harnesses and hard hats and descending on ropes and ladders into an ice cave known as Warren Cave, which has been hollowed out by steam from the volcano. We unclip the harnesses about 40 feet below the surface of the mountain. The floor is moist, soft soil and rocks; the walls are ice. We are here to retrieve a temperature probe—one of 23 the group left on the mountain a year ago in the hopes of determining how much the soil temperatures change and thus whether these environments are relatively stable. As we move away from the entrance, the light fades, and we have to use flashlights. Any microbes living here do not depend on the sun. Now we have entered a cavern that glitters with clusters of delicate, feathery ice crystals. We stop to stare in wonder. Then Moore disappears down a corridor and after a few moments gives a shout. He's found the probe.

Two, we're standing on the rim of Mount Erebus. To get here we've driven as far as we could on snowmobiles, then hiked up a steep, slippery slope of scree—a mix of a glassy pumice and "Erebus crystals," large oblong pieces of feldspar from lava bombs that have been tossed out by the volcano. It's a gorgeous day: The temperature is around minus 13°F, the wind is light, the sky cloudless, the views huge. And the volcano is quiet. Whereas the crater is often full of swirling steam, today we can look down to the bottom, more than 750 feet below, and see the lava lake glowing redly. It's an eerie sight, like looking at a conduit to the center of the Earth.

Up here the air is thin and walking is slow. I'm wearing a thermal shirt, thermal leggings, wool leg warmers, fleece trousers, heavy overalls, a down vest, a fleece jacket, two down jackets, two pairs of socks, heavy boots, three pairs of gloves, a balaclava, a hat, a snowmobile mask, a neck gaiter, ski goggles, and two hoods. Dressed like this, I am bulky and clumsy but warm. Just. As long as we keep moving.

But we've stopped. Herbold is on his hands and knees digging, looking for another of the temperature probes. I hope he finds it soon; I want to start moving again. I have a sudden sense of vulnerability, of being in a landscape that is not benign.

Three, Lower Erebus Hut. Outside, a swirling storm. The door crashes open. Arnold and Moore stride in, their jackets icy, their faces grave. Arnold tosses an ice ax onto the table. It's broken; part of the top has sheared off because of the cold. There will be no ice climbing this afternoon. But we can enter the biggest of the nearby ice towers—the one that looks like an astronaut—and drill an ice core from inside.

Inside, the air is moist and warm. The floor is rocky, with a dusting of ice. Sky is visible through an opening high above. The drill bit looks like a boy-teen fantasy. It's enormous—three feet long—and bright yellow, with a thread of lurid orange. It takes two men to operate, one to cradle it in position, the other to push it into the side of the tower. The interior of the bit is hollow, and pushed like this, it fills with a core of ice, much as an apple corer fills with apple.

Success! Arnold and Cary remove the ice core from the drill bit and stow it in a bag. The hope is that such cores will contain microbes that have been lofted from inside the volcano and then frozen into the ice, giving a window into the microbial life in the vent below.

TWO WEEKS AFTER GOING up the mountain we come down. A few days after that McDonald and Cary and I fly back to New Zealand, along with boxes of samples destined for the laboratory—"where the real work gets done," says Cary. Shortly before the end of the flight a man comes over to McDonald and me and asks if we'd like to come to the cockpit for the landing. Yes please!

We are landing at sunset. Strange how refreshing the impending darkness is—how starved for darkness we have been. Strange too the lush, saturated colors of the New Zealand spring. It's like coming back into a Technicolor world.

It's like coming back to Earth. □

# *Russian Summer*

*Summer, the short, sweet release from the interminable cocoon of Russian winter, is a time for swimming and riding, and sometimes both in the cottage community of Vyalki.*

*At the dacha, the soul of Russia—and its cultural divide—is on display.*

*The dacha is where Russians connect with nature and each other. On weekends (from left) 11-year-old German Shingel; his great-aunt Vera Zhelkina; his mother, Milana; and his grandmother Lyubov Saleyeva gather at their summer home in Valday.*

*By Cathy Newman*

*Photographs by Jonas Bendiksen*

Everyone in Russia has a dacha story. It may be a trace of childhood memory like playing ball late into evening by grace of a sun that won't set, gathering pinecones to perfume the samovar fire, or swimming in an icy pond rimmed by the green spires of spruce.

It may be quietly romantic—a first love that fades with the season or blossoms into marriage. Or a narrative that is poignant, even redemptive. An older woman tells of coming home from work to find her husband in bed with her best friend. She kicked him out and, with retirement looming and no husband, wondered, What will I do now? The answer was the dacha she bought for 500 rubles, with a forest nearby for mushroom hunting, a lake, and a garden. "The dacha saved my life," she says.

The story may be wreathed in sorrow, refracted through the lens of Russia's tragic history. After Natalia Ivanova's grandmother, a young widow with two children, remarried, her new husband bought a dacha outside Moscow. When he disappeared in a Stalinist labor camp, she stayed at the dacha for the rest of her life. "She never sowed anything, even flowers—only grass, which became thicker and thicker," remembers Natalia, a Moscow writer and editor. "A childhood photograph shows it reaching well above my head."

Sweet or bitter, lighthearted or dark, the story always takes place in summer. A dacha, after all, is a summer cottage.

Boris Veshnyakov has dacha stories too. They are muscular, with overtones of swagger. Once he confronted a group of teenagers who were drinking and blasting boomboxes in his dacha community near Valday, a town in northwest Russia. "I picked a couple of them up and dunked them in the lake. Physical force is the only language they understand." Another time, a beefy lout, flouting dacha decorum, let his dog swim in the lake. "I called over my son-in-law, the wrestler. End of problem."

When Boris isn't at the dacha, he's driving a cab. One day while speeding down a road, he pointed out a pit where *dachniks* from big cities open their car doors and fling their garbage. "That's how it is in Russia today," he groused. But Boris had a plan. He was going to set a camera trap to catch offenders.

Until then, Boris, a 63-year-old man with ice-blue eyes, a belly with the contours of an ingested basketball, and an array of short-sleeve shirts with tropical prints more typical of Maui than Moscow, was just Boris the cabdriver to me. Then I discovered his other identity. He was also Chairman Boris, the put-upon leader of Nertsy, a community of a thousand-odd dachas in Valday.

BORIS'S KINGDOM, the realm of the dacha, is a Russian phenomenon. One out of three Russians owns a dacha. In the Moscow region, where there are some one million dachas, Friday night marks the onset of dacha rush hour, in which the laws of inertia decree that a car at rest in dacha traffic stays at rest for a very long time.

The dacha has threaded its way through Russian

*Six-year-old Polina Merkulova hides in the bushes outside her family's dacha near Sergiyev Posad, about 50 miles northeast of Moscow. An hour's drive brings the family from city to country.*

culture ever since Peter the Great handed out land on the outskirts of St. Petersburg to courtiers. ("Dacha" is derived from the Russian verb "to give.") The dacha is the stage upon which the drama (or comedy) of Russian summer unfolds. Summer in Russia is precious and brief; winter, interminable. The growing season in the taiga around St. Petersburg is a short four months. In western Europe it stretches eight months or more. A fifth of Russia is above the Arctic Circle. More than half is underlain by permafrost. The advent of spring, then summer, is a fairy tale of sorts. The soil thaws, as does the soul.

A dacha community is Russia abridged, with its stories of love, loss, and suffering; frictions; conflicting narratives in which everyone seems to have the True Story but no one really does; free-flowing vodka; and opportunities for corruption. (Municipalities grab property illegally and sell it to developers for dacha subdivisions.) It's a place to brood, ponder life, party, cherish the company of family and friends, and more recently it's become a badge of conspicuous, over-the-top consumption for Russia's new money. The dacha is a litmus test for changing Russian values and a celebration of those that stay the same.

Boris's dacha, like most in Valday, is a garden plot with a cabin. Such plots, originally six *sotkas* (.15 acre), date back to Soviet-era land distribution programs that allowed Russians to endure postwar food shortages made worse by the disaster of centrally planned agriculture. With privatization in 1990, owners could buy land and expand beyond six sotkas, but the landscape remains a mishmash of shoulder-to-shoulder dwellings. Decor tends to out-of-date calendars, mismatched crockery, paintings of bears in the forest, and lace curtains hanging in doorways to defend against mosquitoes.

On the other end of the spectrum are *kottedzhy* (cottages), the name for the wannabe castles built by New Russians, postcommunism's superspenders. Many communities of steroidal cottages—there are 500 around Moscow—have

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*Editor at Large Cathy Newman last wrote about Crimea. Jonas Bendiksen is the author of* Satellites, *a photo chronicle of the former Soviet Union.*

*At his Valday dacha Sergey Yudin, deputy director of a pipeline-repair firm, plants, burns weeds, and indulges the "inner peasant" who lives within many Russians. In pinched Soviet times such gardens grew some 90 percent of Russia's vegetables.*

*Boris insists that when Putin visits, scuba divers patrol the lake in front of the compound, which has a Turkish bath, a Russian* banya, *a Chinese teahouse, and a Finnish sauna.*

elbowed aside traditional dachas and sometimes become primary residences. "Oligarchs go to the Loire, see castles, and say: I need one of those," Konstantin Kovalyov-Sluchevskiy, a local historian, says dryly. Interiors tend to early Las Vegas: marble columns that hold up nothing, gilt thick as a call girl's mascara. On the outside are high stone or brick walls, sometimes with slits, as if to allow archers to shoot burning arrows at any peasant foolish enough to attempt a breach. "Their owners have not developed a soul," Konstantin observes sadly.

Valday doesn't have many over-the-top kottedzhy, but it does have a dacha used by Russia's President Vladimir Putin, who drops in from time to time by helicopter. Boris insists that when Putin visits, scuba divers patrol the lake in front of the compound, which has a Turkish bath, a Russian *banya,* a Chinese teahouse, and a Finnish sauna. It might be true; then again, it might not. It isn't easy to know when to take Boris—who believes in angels but has a tattoo of a devil playing guitar on his left shoulder—seriously.

The pride of Valday (population 16,000) is its 390,000-acre national park. The terrain, a slow roll of birch-covered hills dotted by 200 lakes, overlies a watershed that sources two great rivers: the Dnieper and the Volga. Cool, green, quiet, it is an idyllic refuge from the heat of the city. In summer the population doubles, according to an informal census based on bread sales.

Though it is only about 225 miles from Moscow to the south and 180 miles from St. Petersburg to the north, the two cities might as well be on the moon as far as Valday is concerned. Big-city dachniks are regarded as an alien species best avoided, in the way that one tries not to brush against stinging nettles in the forest. Though I suspect he is mistaken, Boris insists that only city folk trash their surroundings; locals would never be so remiss.

It's a cultural divide, says Maxim Semyonov, editor of Valday's weekly. "Our village past is still present. Our first multistory building went up only 40 years ago." City folk, Maxim explains, consider the dacha a place to relax. "In Valday a dacha is about hard work and serious gardening." Nadezhda Yakovleva, a soft-spoken woman with delicate features who runs the local museum, provides more evidence. She points to an 1839 photograph of Muscovites picnicking in Valday. "With French wine and sandwiches," she says in pitying tones. The habits and attitudes of modern-day Muscovites are no better, she implies. "They don't eat healthy. They lie in hammocks and don't worry about bad weather like us. In their kitchen garden, called a supermarket, there will always be crops."

In Boris's community of Nertsy about 30 percent of the thousand dachas are owned by people from St. Petersburg or Moscow. "They have generators and pumps," says Raisa Stepanov, a retired bookkeeper, with a tinge of envy. She has neither. A dacha with no running water or electricity is the rule. Raisa's small wood dacha, painted three different shades of yellow, stands next to a birch tree. Rather it leans on the tree as if for support. There's an outdoor privy in back.

A word about the dacha dress code in Valday: Women favor two-piece bathing suits with a faded '50s look or cotton housedresses. For men: Speedos, sometimes paired with rubber boots. (Why do Russian men wear Speedos? "I don't know, but it is truly Russian," says Melissa Caldwell, a social anthropologist at the University of California, Santa Cruz. "I once almost had to burn my eyes after walking through a park in St. Petersburg and encountering what seemed like thousands of middle-aged men sunbathing in their Speedos.")

Nina Marmashevya, Raisa's best summer friend, joins us for green *schi,* a summer soup made with sorrel. Nina, a sturdy woman with hair the color of paprika, does not so much hug as crush me against her bosom. Small glasses

## A Summer Space

*The dacha follows a historical arc from aristocratic privilege (in the 18th century Peter the Great granted nobles parcels of land on the outskirts of St. Petersburg for summer palaces) to today's modest cottage communities. The map locates communities and places featured in the text.*

appear on the table. Raisa fills them with homemade brandy. Soon the women are pleasantly tipsy, and Nina wanders over to Raisa's garden and starts picking potato beetles off leaves.

It is hard to say if Raisa's garden represents a labor of love or love of labor. Raisa, who is 68, makes fertilizer from compost, waters plants by hand with buckets from a well, and lugs her harvest home in shopping bags on the bus. At the end of summer she has more than 200 jars of preserves to see her through winter. "Each year I say that's it, I am not planting. But then in spring I do."

"So why not taper off?" I suggest. "It doesn't seem terribly relaxing."

"It's relaxing to me," Raisa says.

But a dacha means different things to different generations. Recently her daughter, who has two kids, bought a house in the city. "She is struggling," Raisa says. "I offered to sell my dacha to help her out."

"No, you can't sell it," her daughter said firmly. "At least I can still come here with the kids and go swimming."

VALDAY IS WHERE JOSEPH STALIN had a secret dacha he probably never used. One story says the paranoid dictator took one look at the dacha —known as Object No. 201—at the end of a solitary road at the end of a peninsula and said something like: I'm never staying in that mousetrap. But Valday historian Galina Zimina suggests that Stalin, who had 20 other dachas around the Soviet Union, just never got around to it. "We'll know when they release more of Stalin's archives," she says.

In 1935 Stalin ordered the creation of a dacha colony for writers in Peredelkino, outside of Moscow. In Soviet times political and cultural elites were rewarded with country homes. Artists, party bosses, even cosmonauts, had their own summer compounds. The dacha was the carrot to the stick of the gulag. "Peredelkino was Stalin's way of keeping writers under control," says Konstantin, the historian. "He could keep an eye on them in one place."

In his study on the second floor of his dacha, in the green shade of Peredelkino, Boris

*To stand under the springs at Gremyachiy Klyuch, nine miles from Sergiyev Posad, where a saint once stopped to pray, is to be showered with blessings. Tourists from all over Russia come to collect the holy water—reputed to cure illness—in buckets.*

*"A dacha has no address," Konstantin says. "In detective movies the criminal always hid out in a dacha where he could not be found. A dacha was freedom."*

Pasternak wrote *Doctor Zhivago,* the novel that won him the Nobel Prize in 1958. He accepted. "Proud, astonished, abashed," he wrote the Swedish Academy. The Soviet state thought otherwise. A vicious campaign against him, the possibility of exile, the threat to family (secret police surrounded his dacha) forced him to retract. One can only imagine his pain. At Peredelkino he would tend his garden, bent over, covered with dirt. "The natural world revived him," says the dacha's curator, Irina Samokhina. His tweed cap, plaid scarf, and black overcoat still hang on the wall, as if he had just returned from a walk. Pasternak loved striding across the fields near his dacha, especially the one that led to the church where he prayed. Today the field is covered in newly constructed kottedzhy.

"NERTSY IS NOT A COLLECTION of dachas," Chairman Boris tells me as I sit on the deck of his dacha admiring the lake view. His sister-in-law, who has been drying garlic, brings us a plate of fried fish, sliced cucumbers, and potatoes sprinkled with dill from the garden. There is no such thing as an unfed guest in a Russian dacha.

"It's family," he says. "When my neighbor grieves, I grieve. When I am joyful, so is he." He repeats a common refrain: "There is no conflict. Everyone gets along." True enough, though small irritations that abrade goodwill between neighbors seep out like water from a slowly dripping faucet. Nertsy, unlike the fortress dachas of Moscow suburbs, is a no- or low-fence community, but property lines still matter. Woe to the dachnik whose cucumber vines stray an inch onto public space or an adjacent holding.

A slight chill descends when discussion turns to Katya, a neighbor of Raisa Stepanov's. Katya lives near the path leading to Lake Nertsy. "Her garden keeps edging closer to the lake," Raisa complains. "If her plants get trampled, she has only herself to blame." Scratch a disagreement, and you'll find a boundary issue. When arbitration is required, Boris appears with a survey pole to map the parameters of the dispute.

The penalty for infractions?

"A fine," says Boris. "But just try and find the person to pay the fine." His face darkens. Boris would like someone else to take over the unpaid post of chairman. But no one wants the job.

THE SOIL IS SACRED, almost mystical to Russians, a legacy of pagan beliefs and peasant tradition. "The religion of the soil," philosopher Nikolay Berdyayev called it. A dacha provides the opportunity to dig in that soil and be close to nature. "By the end of the day I am tired and stressed," a Valday woman tells me. "I go to the garden, touch the ground, and bad things go away."

In July the soil yields cucumbers and feathery dill, also squash, peas, and green onions. July is for berries: black, red, and white currants; blueberries; blackberries; raspberries; gooseberries; and delicately perfumed wild strawberries, which, even more than the resinous astringency of pine, is the smell of summer. August brings mushrooms (a light rain is known as a "mushroom rain"): the prized *biali,* or white mushroom, and boletes that grow near birch trees and can be dried. Also potatoes—always potatoes. A Valday garden is unthinkable without them, although they cost less to buy than grow.

Galina Yertseva, an economist for the town, grows potatoes along with her two sons' families and her in-laws. "Why? It's in the blood," she says. Perhaps, I suggest, it's a genetic memory associated with times of famine, like after World War II, when people picked over fields for rotten potatoes to mix with weeds to make flour. Galina agrees. Her six-year-old granddaughter is playing in the garden. I ask if she has any aptitude for growing potatoes. "Hardly," Galina answers.

The work of growing food may be an instinct passed on from generations that knew hardship, but a younger generation with no such memory

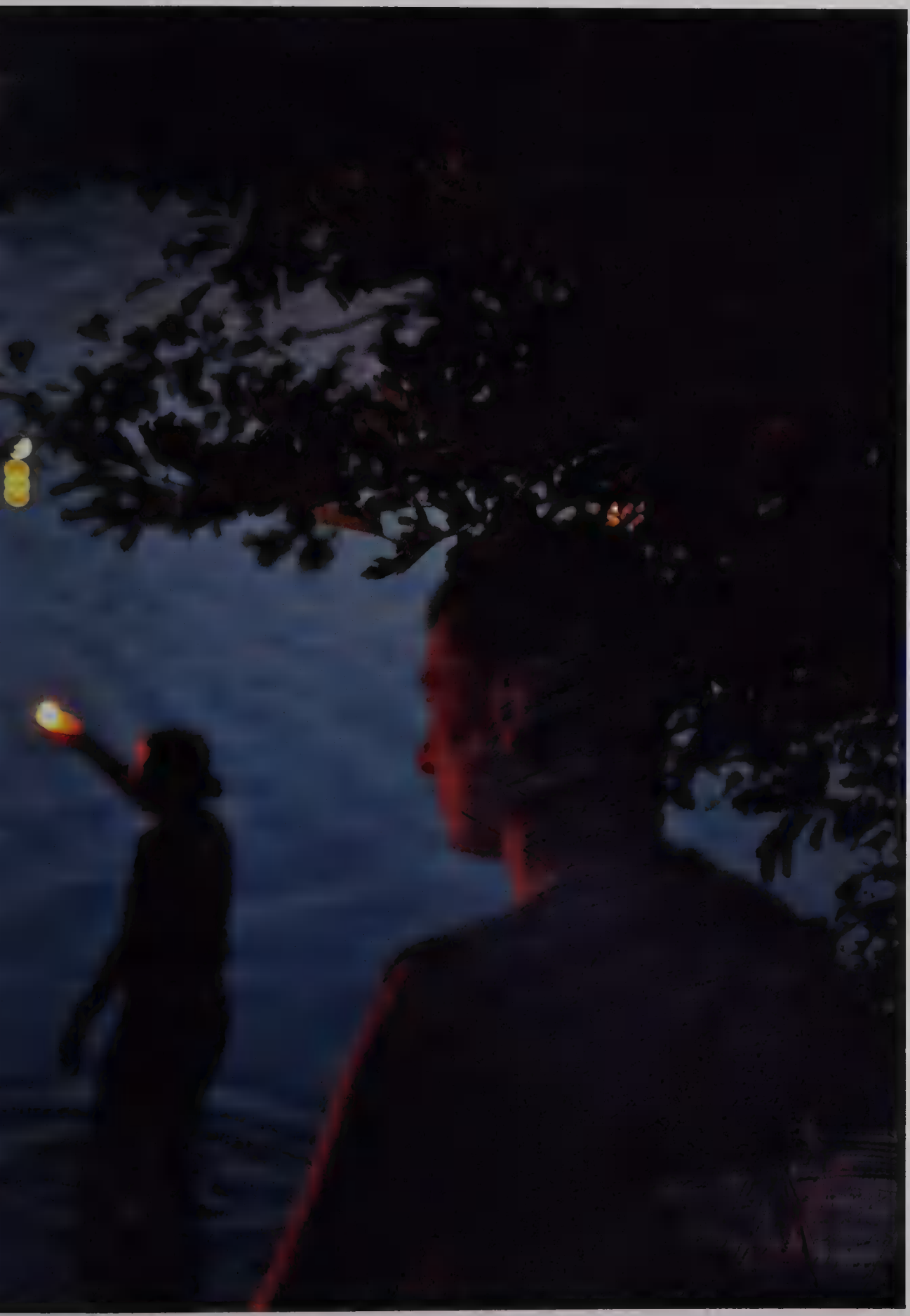
*At the lavish end of the dacha spectrum are faux châteaux like these at Zelenyy Mys. Roughly half are permanent residences. A helicopter landing pad and yacht club are among the amenities for well-heeled owners.*

or interest is stepping into place. "Given a good enough economy, I think in the future the dacha will be purely for investment and entertainment and not a source of food," says researcher Tatyana Nefedova of the Institute of Geography in Moscow. As the dacha shifts from the Soviet-era ideal place for dutiful toil to a retreat for the sheer fun of it, the decorative replaces the practical: flowers instead of potatoes, plaster gnomes instead of onions.

In Soviet times the dacha also was a respite from the communal apartment. In a world where the word "private" was missing from the dictionary and a drape served as a wall, the dacha provided room to breathe and escape from watchful eyes. "A dacha has no address," Konstantin says. "In detective movies the criminal always hid out in a dacha where he could not be found. A dacha was freedom."

Now that the Iron Curtain has been lifted and Russians can come and go as they please, there is a wider world beyond the dacha. In 2011 three times as many Russians traveled abroad for summer vacation as in 1997. "When our daughter was little she came to the dacha," says Tatyana. "Now she prefers Croatia." "Visiting is good, but home is better," a Russian proverb avers. Sometimes we need distance to appreciate what is near at hand. Will a more affluent and worldly generation of young Russians buy into that thought and cherish the homely dachas of their parents? Naturally, Boris, from his summit view at Nertsy, has a story about that too.

One day his 30-year-old daughter, Vladislava, came home to visit after a trip abroad. "She travels everywhere," Boris says. "Egypt, Italy, Turkey." This time,Vladislava, who works in advertising and lives in St. Petersburg, had gone to comfortable, orderly Switzerland. But Vladislava had had her fill of Swiss perfection. Now she longed for the familiar warmth of cobbled-together, unruly Nertsy. She sat on the deck of the family dacha and gazed at the calm, green oval of Lake Nertsy. Sunbathers stretched out on half-sunken docks splintered by winter ice. Water lilies floated like tiny yellow coronets. "Lake Geneva," she said airily. "It's just a pond." □



*Midsummer Night, known as the festival of Ivan Kupala (St. John the Baptist), is marked by candles and flower garlands in Vladimirskoye. Celebrants walk three times around Svetloyar Lake, which legend says makes wishes come true.*

*Barrel-bellied bathers (above), picnicking near the Dubna River, are as much a part of the summer scenery as grilled meat and beer. German Shingel fills a tub for watering the garden under the watchful eye of his father, Yevgeniy (below). To outwit Russia's short growing season, many dacha owners set flats of seedlings on their urban windowsills in March.*

*Shoes and inhibitions are shed (above) during a party at a dacha belonging to a Muscovite in the film industry. Like many, Anna Merkulova (below) is a weekend* dachnik. *She returns to Moscow on Mondays for her job as a dog groomer, leaving her children, Polina and Yegor, behind in the hands of their grandmother.*

# Deepwater Horizon Oil Spill

## *Economic and Property Damages Settlement*

### Providing Money to Individuals and Businesses

If you have economic loss or property damage because of the Deepwater Horizon oil spill, you could get money from a class action settlement with BP Exploration & Production Inc. and BP America Production Company ("BP"). Go to DeepwaterHorizonSettlements.com for more information, including information on how to file a claim.

#### WHO IS INCLUDED IN THE ECONOMIC & PROPERTY DAMAGES SETTLEMENT?

The Economic and Property Damages ("E&PD") Settlement Class includes people, businesses, and other entities in the states of Louisiana, Alabama and Mississippi, and certain counties in Texas and Florida, that were harmed by the oil spill. The website DeepwaterHorizonSettlements.com has detailed descriptions and maps to help you determine whether a geographic location may be included in the E&PD Settlement. Additionally, you can call 1-866-992-6174 or e-mail questions@DeepwaterHorizonEconomicSettlement.com to find out if a geographic location is included.

#### WHAT DOES THE ECONOMIC & PROPERTY DAMAGES SETTLEMENT PROVIDE?

The E&PD Settlement makes payments for the following types of claims: (1) Seafood Compensation, (2) Economic Damage, (3) Loss of Subsistence, (4) Vessel Physical Damage, (5) Vessels of Opportunity Charter Payment, (6) Coastal Real Property Damage, (7) Wetlands Real Property Damage, and (8) Real Property Sales Damage. There is no limit on the total dollar amount of the E&PD Settlement; all qualified claims will be paid.

#### HOW TO GET BENEFITS FROM THE ECONOMIC & PROPERTY DAMAGES SETTLEMENT

You need to submit a Claim Form to request a payment. You can get a copy of the various Claim Forms by visiting the website or by calling 1-866-992-6174. Claims can be submitted online or by mail. If you have questions about how to file your claim, you should call the toll-free number for assistance.

The deadline to submit most E&PD claims w be April 22, 2014 or six months after the E&P Settlement becomes effective (that is, after the Cou grants "final approval" and any appeals are resolved whichever is later. There will be an earlier deadli to submit E&PD Seafood Compensation claims. T earlier deadline to submit Seafood Compensati claims will be 30 days after final approval of t Settlement by the United States District Court for t Eastern District of Louisiana (regardless of appeals Actual claim filing deadlines will be posted on t website as they become available. Valid clair will be paid as they are approved, beginning short after the Court-Supervised Settlement Progra commences. It is highly recommended that E&P Settlement Class Members complete and subm their claim forms promptly. Please read the Medic Benefits Settlement notice because you may also eligible for benefits from that settlement.

#### YOUR OTHER OPTIONS

If you do not want to be legally bound by the E&P Settlement, you must Opt Out or exclude yourself **October 1, 2012** or you won't be able to sue BP ov certain economic and property damage claims. you stay in the E&PD Settlement, you may object it by **August 31, 2012**. The Detailed Notice explai how to exclude yourself or object.

The Court will hold a hearing on **November 8, 201** to consider whether to approve the E&PD Settlemer You or your own lawyer may ask to appear and spea at the hearing at your own cost. The Court will al consider Class Counsel fees, costs, and expens including an interim payment of $75 million ar additional awards equal to 6% of class clair and benefits paid. Class Counsel fees, costs ar expenses under the Economic and Property Damag Settlement Agreement and the Medical Benefi Settlement Agreement jointly cannot exceed $6( million. Class members' payments will not be reduce if the Court approves the payment of Class Couns fees, costs, and expenses because BP will separate pay these attorney fees, costs, and expenses.

# Deepwater Horizon Oil Spill

## *Medical Benefits Settlement*

### Providing Benefits to Clean-Up Workers and Certain Gulf Coast Residents

If you have a medical claim related to the Deepwater Horizon oil spill, you could get benefits from a class action settlement with BP Exploration & Production Inc. and BP America Production Company ("BP"). Go to DeepwaterHorizonSettlements.com for more information, including information on how to file a claim.

#### WHO IS INCLUDED IN THE MEDICAL BENEFITS SETTLEMENT?

The Medical Class includes (1) clean-up workers and (2) certain people who resided in specific geographic areas in coastal and wetlands areas along the Gulf Coast during specific periods in 2010. The website DeepwaterHorizonSettlements.com has detailed descriptions and maps to help you determine whether a geographic location may be included in one of these zones. Additionally, you can call 1-866-992-6174 or e-mail info@DeepwaterHorizonMedicalSettlement.com to find out if a geographic location is included.

#### WHAT DOES THE MEDICAL BENEFITS SETTLEMENT PROVIDE?

The benefits of the Medical Benefits Settlement include: (1) payments to qualifying people for certain acute (short-term) and chronic (ongoing) medical conditions occurring after exposure to oil or chemical dispersants; (2) provision of periodic medical examinations to qualifying people; and (3) creation of a Gulf Region Health Outreach Program, consisting of projects to strengthen the healthcare system. Benefits (1) and (2) will be provided only after the Court grants final approval and any appeals are resolved.

#### HOW TO GET BENEFITS FROM THE MEDICAL BENEFITS SETTLEMENT

You need to submit a Claim Form to request benefits. You can get a copy of the Claim Form by visiting the website or by calling 1-866-992-6174. Claims can be submitted by mail. If you have questions about how to file your claim, you should call the toll-free number for assistance.

The deadline for filing a Claim Form is one year after the Medical Benefits Settlement becomes effective (that is, after the Court grants "final approval" and any appeals are resolved). The exact date of the claim filing deadline will be posted on the website. It is highly recommended that Medical Class Members complete and submit their claim forms promptly. Please read the Economic and Property Damages Settlement notice because you may also be eligible for a payment from that settlement.

#### YOUR OTHER OPTIONS

If you do not want to be legally bound by the Medical Benefits Settlement, you must Opt Out or exclude yourself by **October 1, 2012** or you won't be able to sue BP over certain medical claims. If you stay in the Medical Benefits Settlement, you may object to it by **August 31, 2012**. The Detailed Notice explains how to exclude yourself or object.

The Court will hold a hearing on **November 8, 2012** to consider whether to approve the Medical Benefits Settlement. You or your own lawyer may ask to appear and speak at the hearing at your own cost. Class Counsel will ask the Court to consider an award of fees, costs, and expenses of 6% of the value of the benefits actually provided under the Medical Benefits Settlement Agreement. Class Counsel fees, costs, and expenses under the Medical Benefits Settlement Agreement and the Economic and Property Damages Settlement Agreement jointly cannot exceed $600 million. Class members' payments will not be reduced if the Court approves the payment of Class Counsel fees, costs, and expenses because BP will separately pay these attorney fees, costs, and expenses.

# NG CONNECT

Every month this page features our staff picks of National Geographic Society products and events. For more go to *nglive.org*.

## NATIONAL GEOGRAPHIC ON TV

### The Hutterites

Like most families, they bicker now and then. Yet this group from rural Montana is hardly typical. Meet the Hutterites of King Colony (left). Their conservative way of life revolves around worship and work, but modern technology and higher education are tempting some to break away. It's all about reconciling the past with the present, this month on the National Geographic Channel.

**WORKSHOP**

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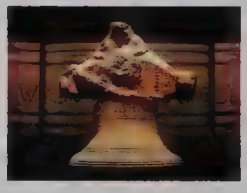

**REAL PIRATES** Let the high seas adventure unfold as you explore a pirate ship that sank off the coast of Cape Cod in 1717. Learn about the people aboard, and view more than 200 objects recovered—including treasure, weaponry, and the ship's bell (left)—at the Science Museum of Minnesota through September 3. Visit *smm.org*.

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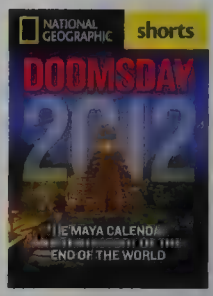


**Free Download of the Month**

**Bibi Tanga and the Selenites** *40° of Sunshine*

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PHOTOS: BEN SHANK, COLLINS AVENUE (TOP); KENNETH GARRETT (BELL)

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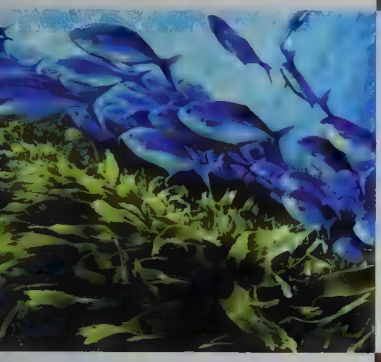
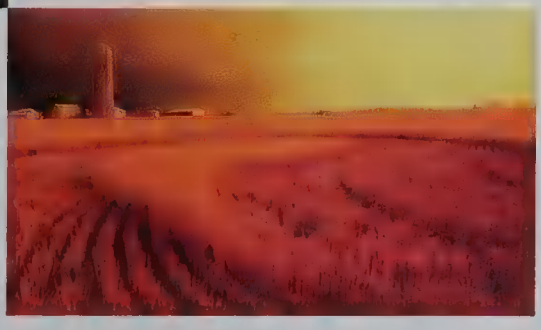


# living in THE NEW NORMAL

Feeding the Planet



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# A Mystical Coat and Hat

Lynn Johnson faced a daunting task: make photos that embody the cultures of little-known or vanishing languages. In some cases she began with a certain word or phrase; other times she relied on instinct to find a captivating image.

In the Republic of Tuva, in Russia, Johnson visited a center where shamans counsel suffering souls. "People unburden their hearts and minds of things they feel are sabotaging their lives," she says. She saw this shaman in her ceremonial headdress and coat (right), adorned with objects believed to ward off evil: a copper disk, braided ribbons, wild boar tusks. The scene evokes the Tuvan word *eeren,* meaning protector spirit. *—Luna Shyr*

BEHIND THE LENS

## How do the coat and headdress tie in with the spiritual beliefs of the Tuvans?

**LJ:** Every object on the shaman coat is local or symbolizes something local, and the shamans wear their coat and headdress when they perform ceremonies. The Tuvan people are very tied to the land and the wind—to all things that are natural. They believe that mountains, rivers, the world are imbued with spirits, so you have to live in concert with these spirits, and the Tuvan language reflects that. You can call it superstition, but it's really their worldview.

**Why do the people of Tuva go to shaman centers?**

If you had a broken heart, you would ask for [one] person. If you had financial problems, you would ask for another. What seemed most interesting to me was how everyday the visits were, like going to the dentist or doctor.

The shamans had offices, and if they weren't performing a ceremony, they'd usually be at their desk, maybe on the phone, doing everyday stuff. On the walls they'd hang their coats and other sacred objects.

Their coats aren't just a source of power, inspiration, and identity. They're also protection, because of the individual totems sewn into them. Because the shamans were around people who were sick or needed help all the time, they'd wear the coats and a copper or gold disk to protect themselves.

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# Sent Messages

These smoke signals were staged on a hilltop in Montana in 1909 for the book *The Vanishing Race*. The tribe of the messenger is unknown, but nearly all Plains Indians used this speedy form of sending news.

The book's author, Joseph K. Dixon—an ethnographer sent by President William Howard Taft to document the disappearing traditions of Native Americans—became more than an objective observer. According to his book's acknowledgments, while on a later expedition that spanned 26,000 miles and 189 tribes, Dixon was adopted by the Wolf clan of the Mohawk Nation and given the name of Ka-ra-Kon-tie, or Flying Sun. *—Johnna Rizzo*

**Flashback Archive** Find all the photos at **ngm.com.**

PHOTO: JOSEPH K. DIXON, NATIONAL GEOGRAPHIC STOCK

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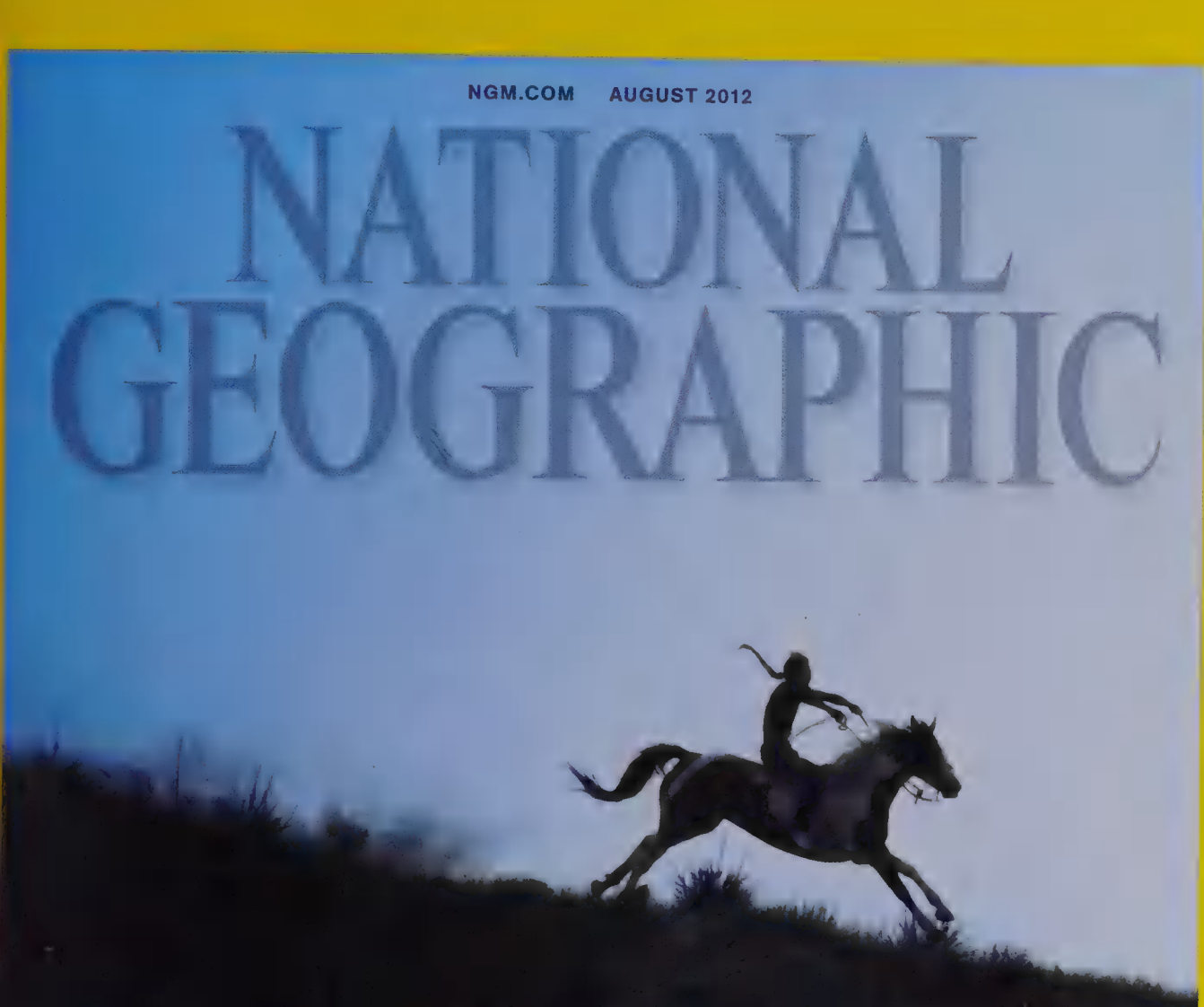

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VOL. 222 • NO. 2

# NATIONAL GEOGRAPHIC

*Just boil a few in a cup of tea, and all that ails you will be healed.*
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CARSTEN PETER

THE MEMBERS' JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY

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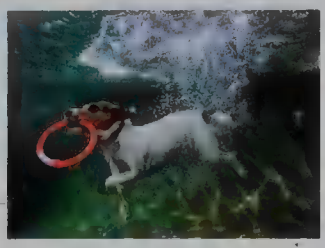

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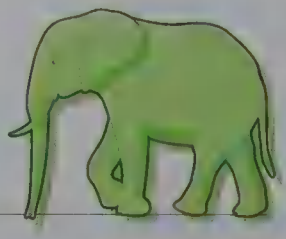

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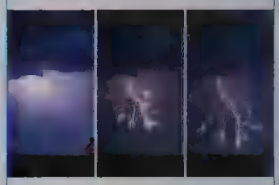

**Lightning**
Video
*A high-speed camera lets us show bolts in slo-mo.*

**Pine Ridge**
Audio and Video
*Oglala Lakota speak of horses, poverty, and hope; strike a pose for our cover.*

PHOTOS: CARSTEN PETER (TOP); AARON HUEY

**On the Cover**
Horse races are part of the yearly Oglala Lakota commemoration of the 1876 victory over Lt. Col. George A. Custer, held near Manderson, South Dakota.
*Photo by Aaron Huey*

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Award-winning photographer Raymond Gehman's images have appeared in *National Geographic* and other publications. He lives in Waynesboro, Pennsylvania.

# RAYMOND GEHMAN

My first national park memory dates back to when I was eight and my parents piled all of us kids into the car to spend the day on Skyline Drive in Shenandoah National Park. My dad took snapshots of the family posed in front of the overlooks. Fast-forward many years and I was working as a photojournalist for a large newspaper. One day, *National Geographic* called and offered me my first big assignment, documenting Yellowstone National Park through all four seasons. It was there that I discovered an affinity for photographing landscapes and wildlife.

I have shot nearly every national park in the country. This image from the Great Smoky Mountains National Park showcases Sugarland Mountain in spectacular autumn colors, viewed from the Chimney Tops Trail. The sun's backlighting brings a lively luminescence to the sea of trees. The national parks offer everyone a chance to experience America as it once was, a grand, mysterious, and challenging environment. When you climb to the top of a rocky peak, it allows you to connect with something much larger than yourself.

# MY VIEW

## Capturing Luminescence in Great Smoky Mountains National Park

This is Raymond's view.
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Photos: Raymond Gehman

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# Embracing the Spirit

On a windswept hill in South Dakota 25 years ago, in a small, traditional sweat lodge, I watched and photographed Robert Fast Horse and Ron Mousseau practicing a time-honored ritual in temperatures that would send most mortals fleeing. Seemingly oblivious to the scorching heat, they prayed and chanted as their Oglala Lakota forefathers had for generations. In embracing the ceremony known to them as *inipi,* or rite of purification, they were coping with the reality of living on the Pine Ridge Reservation, one of the poorest, most depressed regions of the United States.

**They prayed as their Oglala Lakota forefathers had.**

Chief Oliver Red Cloud leads the parade at the annual Oglala Nation Pow Wow in Pine Ridge, South Dakota. The 94-year-old is a descendant of the famous Chief Red Cloud.

They were coping as well with the scars left by one of the most brutal events in American history: the massacre at Wounded Knee, where Oglala men, women, and children were killed by members of the U.S. Seventh Cavalry Regiment on a winter day in 1890.

This month writer Alexandra Fuller and photographer Aaron Huey report that the spirit I witnessed in that sweat lodge is growing. The people of Pine Ridge still battle poverty, and—as Olowan Thunder Hawk Martinez, a 38-year-old activist, told Fuller—the weight of a tragic history continues to press down. But across the reservation there is a powerful resurgence of traditional values. It is nothing less than a spiritual rebirth, and with that comes hope. "When we honor our customs…we have everything we need to heal ourselves within ourselves," Martinez said. I am certain she is right. I saw and felt the power of that rich culture myself, years ago, on that windswept hill in South Dakota.

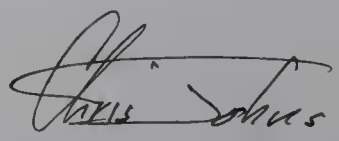



PHOTO: AARON HUEY

# I DISCOVERED SOUTH AMERICA'S OLDEST INDIGENOUS TRIBES AND ITS MOST UNSPOILT BEACHES MOUNTAIN BIKING DOWN VOLCANOES A LUXURY HOTEL DEEP WITHIN THE RAINFOREST AND THE GALAPAGAN FOUR EYED FISH IN ECUADOR

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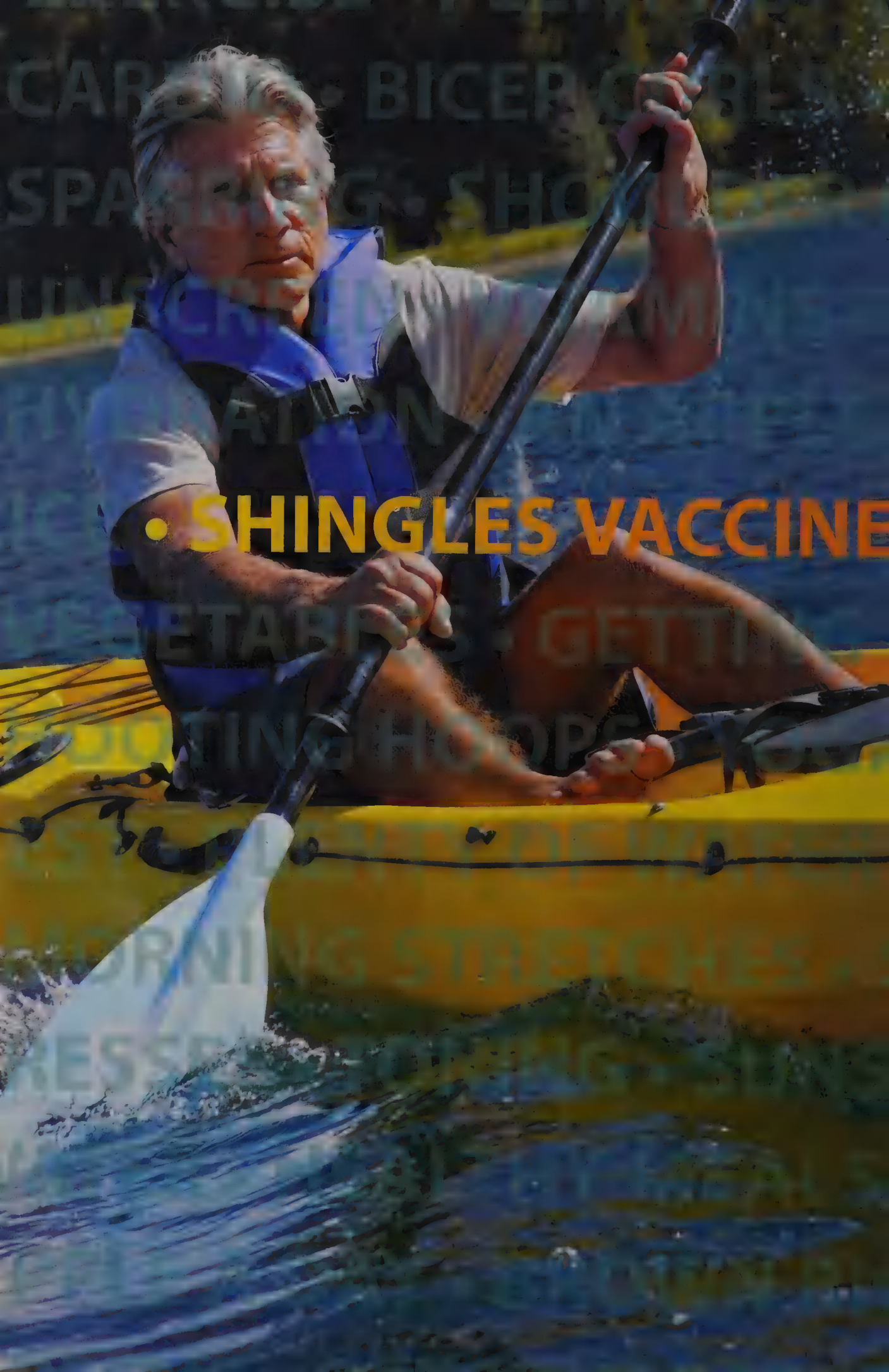
• SHINGLES VACCINE

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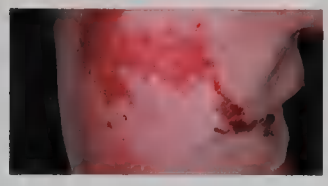

TAVAX is a vaccine that helps prevent Shingles in adults 50 years of age lder. Shingles is caused by the same virus that causes chickenpox. The s stays in your body and can resurface at any time as Shingles—a painful, tering rash. And no matter how healthy you feel, your risk increases as get older.

sooner you get vaccinated with ZOSTAVAX, the better your chances of tecting yourself from Shingles. In fact, the ACIP* of the CDC (Centers for Disease Control and Prevention) ommends that appropriate adults 60 years of age and older get vaccinated to help prevent Shingles.

## k to your health care professional to see if ZOSTAVAX is right for you.

TAVAX is given as a single shot. ZOSTAVAX cannot be used to treat Shingles, or the nerve pain that may w Shingles, once you have it. For more information, visit ZOSTAVAX.com or call 1-877-9 SHINGLES.

## OUT ZOSTAVAX

TAVAX is a vaccine that is used for adults 50 years of age or older to prevent Shingles (also known as zoster).

## portant Safety Information

STAVAX does not protect everyone, so some people who get the vaccine may still get Shingles.

u should not get ZOSTAVAX if you are allergic to any of its ingredients, including gelatin or neomycin, ve a weakened immune system, take high doses of steroids, or are pregnant or plan to become egnant. You should not get ZOSTAVAX to prevent chickenpox.

k to your health care professional if you plan to get ZOSTAVAX at the same time as PNEUMOVAX®23 neumococcal Vaccine Polyvalent) because it may be better to get these vaccines at least 4 weeks apart.

ssible side effects include redness, pain, itching, swelling, hard lump, warmth, or bruising at the ection site, as well as headache.

STAVAX contains a weakened chickenpox virus. Tell your health care professional if you will be in close ntact with newborn infants, someone who may be pregnant and has not had chickenpox or been ccinated against chickenpox, or someone who has problems with their immune system. Your health re professional can tell you what situations you may need to avoid.

are encouraged to report negative side effects of prescription drugs to the FDA. www.fda.gov/medwatch or call 1-800-FDA-1088.

se read the Patient Information on the adjacent page for more detailed information.

=Advisory Committee on Immunization Practices

**fore you get Shingles, get vaccinated.**

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# Patient Information about ZOSTAVAX® (pronounced "ZOS tah vax") Generic name: Zoster Vaccine Live

9989115

You should read this summary of information about ZOSTAVAX before you are vaccinated. If you have any questions about ZOSTAVAX after reading this page, you should ask your health care provider. This information does not take the place of talking about ZOSTAVAX with your doctor, nurse, or other health care provider. Only your health care provider can decide if ZOSTAVAX is right for you.

**What is ZOSTAVAX and how does it work?**

ZOSTAVAX is a vaccine that is used for adults 50 years of age or older to prevent shingles (also known as zoster).

ZOSTAVAX contains a weakened chickenpox virus (varicella-zoster virus).

ZOSTAVAX works by helping your immune system protect you from getting shingles.

If you do get shingles even though you have been vaccinated, ZOSTAVAX may help prevent the nerve pain that can follow shingles in some people. ZOSTAVAX does not protect everyone, so some people who get the vaccine may still get shingles.

ZOSTAVAX cannot be used to treat shingles, or the nerve pain that may follow shingles, once you have it.

**What do I need to know about shingles and the virus that causes it?**

Shingles is caused by the same virus that causes chickenpox. Once you have had chickenpox, the virus can stay in your nervous system for many years. For reasons that are not fully understood, the virus may become active again and give you shingles. Age and problems with the immune system may increase your chances of getting shingles.

Shingles is a rash that is usually on one side of the body. The rash begins as a cluster of small red spots that often blister. The rash can be painful. Shingles rashes usually last up to 30 days and, for most people, the pain associated with the rash lessens as it heals.

**Who should not get ZOSTAVAX?**

You should not get ZOSTAVAX if you:

- are allergic to any of its ingredients.
- are allergic to gelatin or neomycin.
- have a weakened immune system (for example, an immune deficiency, leukemia, lymphoma, or HIV/AIDS).
- take high doses of steroids by injection or by mouth.
- are pregnant or plan to get pregnant.

You should not get ZOSTAVAX to prevent chickenpox.

Children should not get ZOSTAVAX.

**How is ZOSTAVAX given?**

ZOSTAVAX is given as a single dose by injection under the skin.

**What should I tell my health care provider before I get ZOSTAVAX?**

You should tell your health care provider if you:

- have or have had any medical problems.
- take any medicines, including non-prescription medicines, and dietary supplements.
- have any allergies, including allergies to neomycin or gelatin.
- had an allergic reaction to another vaccine.
- are pregnant or plan to become pregnant.
- are breast-feeding.

Tell your health care provider if you expect to be in close contact (including household contact) with newborn infants, someone who may be pregnant and has not had chickenpox or been vaccinated against chickenpox, or someone who has problems with their immune system. Your health care provider can tell you what situations you may need to avoid.

**Can I get ZOSTAVAX with other vaccines?**

Talk to your health care provider if you plan to get ZOSTAVAX at the same time as the flu vaccine.

Talk to your health care provider if you plan to get ZOSTAVAX at the same time as PNEUMOVAX®23 (Pneumococcal Vaccine Polyvalent) because it may be better to get these vaccines at least 4 weeks apart.

**What are the possible side effects of ZOSTAVAX?**

The most common side effects that people in the clinical studies reported after receiving the vaccine include:

- redness, pain, itching, swelling, hard lump, warmth, or bruising where the shot was given.
- headache

The following additional side effects have been reported with ZOSTAVAX:

- allergic reactions, which may be serious and may include difficulty in breathing or swallowing. If you have an allergic reaction, call your doctor right away.
- chickenpox
- fever
- hives at the injection site
- joint pain
- muscle pain
- nausea
- rash
- rash at the injection site
- swollen glands near the injection site (that may last a few days to a few weeks)

Tell your health care provider if you have any new or unusual symptoms after you receive ZOSTAVAX. For a complete list of side effects, ask your health care provider.

Call 1-800-986-8999 to report any exposure to ZOSTAVAX during pregnancy.

**What are the ingredients of ZOSTAVAX?**

Active Ingredient: a weakened form of the varicella-zoster virus.

Inactive Ingredients: sucrose, hydrolyzed porcine gelatin, sodium chloride, monosodium L-glutamate, sodium phosphate dibasic, potassium phosphate monobasic, potassium chloride.

This page summarizes important information about ZOSTAVAX. If you would like more information, talk to your health care provider or visit the website at www.ZOSTAVAX.com or call 1-800-622-4477.

**Rx only**

Issued June 2011

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Whitehouse Station, NJ 08889, USA
VACC-1016603-0025 05/12

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# It's a first. It's silver. It's patriotic. And it's a steal.

Washington crossing the Delaware. Eisenhower launching D-Day. Kennedy rescuing the crew of PT 109. These men made history.

## This set made history

To celebrate the bicentennial of America, the U.S. Mint struck this special three-piece proof set honoring these three American presidents—and our 200th birthday. To capture the bicentennial spirit, the coins in the set are dual–dated 1776–1976.

This set was so popular over 4 million were sold.

Unlike the regular circulating coins of the day, these coins are struck in 40% precious silver.

It's the first commemorative U.S. Mint Proof Set *ever*. It's also the first proof set to feature all dual-dated coins. And finally, it's the first U.S. Proof Set to include a Silver Dollar.

Americans love proof coins from the U.S. Mint. Each coin is struck twice from specially prepared dies and has deeply-mirrored surfaces and superb frosty images.

And you know you've got a *real piece of American history* when you hold this set—the red white and blue holder is spectacular!

## Now for the steal part...

This first-ever Bicentennial Silver Proof Set sold out at the mint three decades ago. When you consider how much prices have risen since then, you might expect to pay $100 *or more* to buy this set today.

But for this special offer, we are releasing our entire stock of Bicentennial Silver Proof Sets for only $49 each. *Or better yet, buy five and pay only $39 each!*

## Order now risk free

We expect our small quantity of Bicentennial Silver Proof Sets to disappear quickly at this special price. We urge you to call now to get yours. You must be satisfied with your set or return it within 30 days of receipt for a prompt refund (less s&h).

## Buy more and SAVE

1776-1976 Bicentennial Silver Proof Set $49 + *s/h*
5 for only $39 each + *s/h*
**SAVE $50**

Toll-Free 24 hours a day
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BBB ACCREDITED BUSINESS

# Titanic

I would not fully agree with Robert Ballard and Eva Hart that the *Titanic* is a gravesite. By their definition, wouldn't all wrecks from the earliest points of history be considered gravesites? Is the *Titanic* more of a gravesite because of the modern tragedy of the event, the media coverage, the red-carpet list of passengers, the poor, and yes, the crew? When does a wreck not become a gravesite? What about a wreck that contains gold, silver, or historical treasure? *Titanic* was a great loss indeed, but when you compare that sinking with the losses during World War I, there is no comparison.

**THADDEUS B. KUBIS**
**Sheffield, Massachusetts**

Since *Titanic*'s discovery, she has been photographed, filmed, analyzed, and sadly, robbed. Let us now leave her and her dead in peace on the ocean floor and move on.

**NICK HART**
**Beverley, England**

I was intrigued by the photo on page 82, the group of workers at the Belfast shipyard. To the immediate left is a worker who appears to be a ghost. I can see right through him to the rivets behind him. Intriguing, to say the least.

**DAVID MECHAM**
**Seattle, Washington**

*According to Bill Sauder, the RMS Titanic, Inc.'s director of* Titanic *research, the ghostly appearance is most likely due to an attempt to improve the composition of the photo by removing the figure standing in a pit. The figure probably wouldn't have been visible in the newspapers of 1912, which had very poor black-and-white contrast.*

The article refers to *Titanic* as "the greatest ship that ever sailed." Maybe in 1912 it was the greatest ship, but there have been many great ships built in the past hundred years. The *Titanic* was a beautiful vessel, inside and out, but it did not even complete its first voyage. I think the author got a little carried away with the legend.

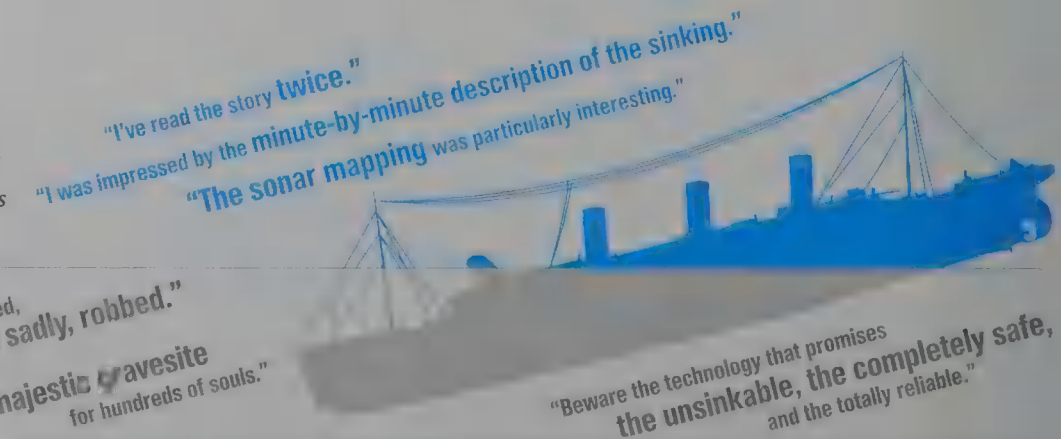
**CHUCK JOHNSON**
**Irving, Texas**

Page 95 reads: "No ship since the *Titanic* has been sunk by an iceberg in the North Atlantic." On January 30, 1959, the Danish ship *Hans Hedtoft* sank south of Greenland after striking an iceberg. It was well north of the route of the *Titanic* but still in the Atlantic.

**NIELS MØLLER CHRISTENSEN**
**Viborg, Denmark**

Hans Hedtoft*'s telegrapher sent an SOS that the ship had collided with an iceberg, but no visual confirmation was ever made.*

**FEEDBACK** *Some readers responded to the technical aspects of the* Titanic *story, others focused on emotion.*


"I've read the story twice."
"I was impressed by the minute-by-minute description of the sinking."
"The sonar mapping was particularly interesting."
"She has been photographed, filmed, analyzed, and sadly, robbed."
"A majestic gravesite for hundreds of souls."
"Beware the technology that promises the unsinkable, the completely safe, and the totally reliable."

**EMAIL** ngsforum@ngm.com **TWITTER** @NatGeoMag **WRITE** National Geographic Magazine, PO Box 98199, Washington, DC 20090-8199. Include name, address, and daytime telephone. Letters may be edited for clarity and length.



GRAPHIC: JOHN TOMANIO, NGM STAFF

NATIONAL GEOGRAPHIC

# Give An *Inspiring* Gift

**Pat Minnick included National Geographic in her financial plans.**

In 2007 Pat Minnick, a professional artist, decided to establish a charitable gift annuity to support National Geographic.

"I feel good knowing that National Geographic is doing so much to protect endangered wildlife," says Pat. "The environmental problems we face are vast, but by joining with National Geographic and their history of remarkable accomplishments, I know we can pass on a more beautiful world."

Pat now receives a guaranteed life income and is a direct part of the Society's efforts to inspire people to care about the planet.

For more information about a charitable gift annuity or other ways to include National Geographic in your estate plans, please see below.

## SAMPLE ANNUITY RATES FOR ONE BENEFICIARY

*(Rates at other ages available upon request.)*

**Age 65=4.7% Age 75= 5.8% Age 85=7.8%**

*Rates are subject to change.*
*Please contact us for the most current rates.*

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To National Geographic, please use the following language: "To the National Geographic Society in Washington, D.C., I give _____% of my estate." Or you can name a fixed dollar amount.

## CONTACT US:

Phone: (800) 226-4438
Email: plannedgiftinfo@ngs.org
Web: www.nationalgeographic.org/donate

The National Geographic Society is a 501(c)(3) tax-exempt organization.

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*Minimum age 50. Payments begin at age 60.*

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☐ Send me information on including National Geographic in my will.
☐ I have already included National Geographic in my will.

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Mail to: National Geographic Society
Office of Estate Planning
1145 17th Street N.W.
Washington, D.C. 20036-4688

Please Neglect

# VISIONS

**United States**
It's splashdown for Lulu, a Parson Russell terrier playing underwater fetch in a Phoenix, Arizona, pool. The climbing moment required familiarity with the photographer, about ten dive attempts, aquatic acuity, and perfect timing.

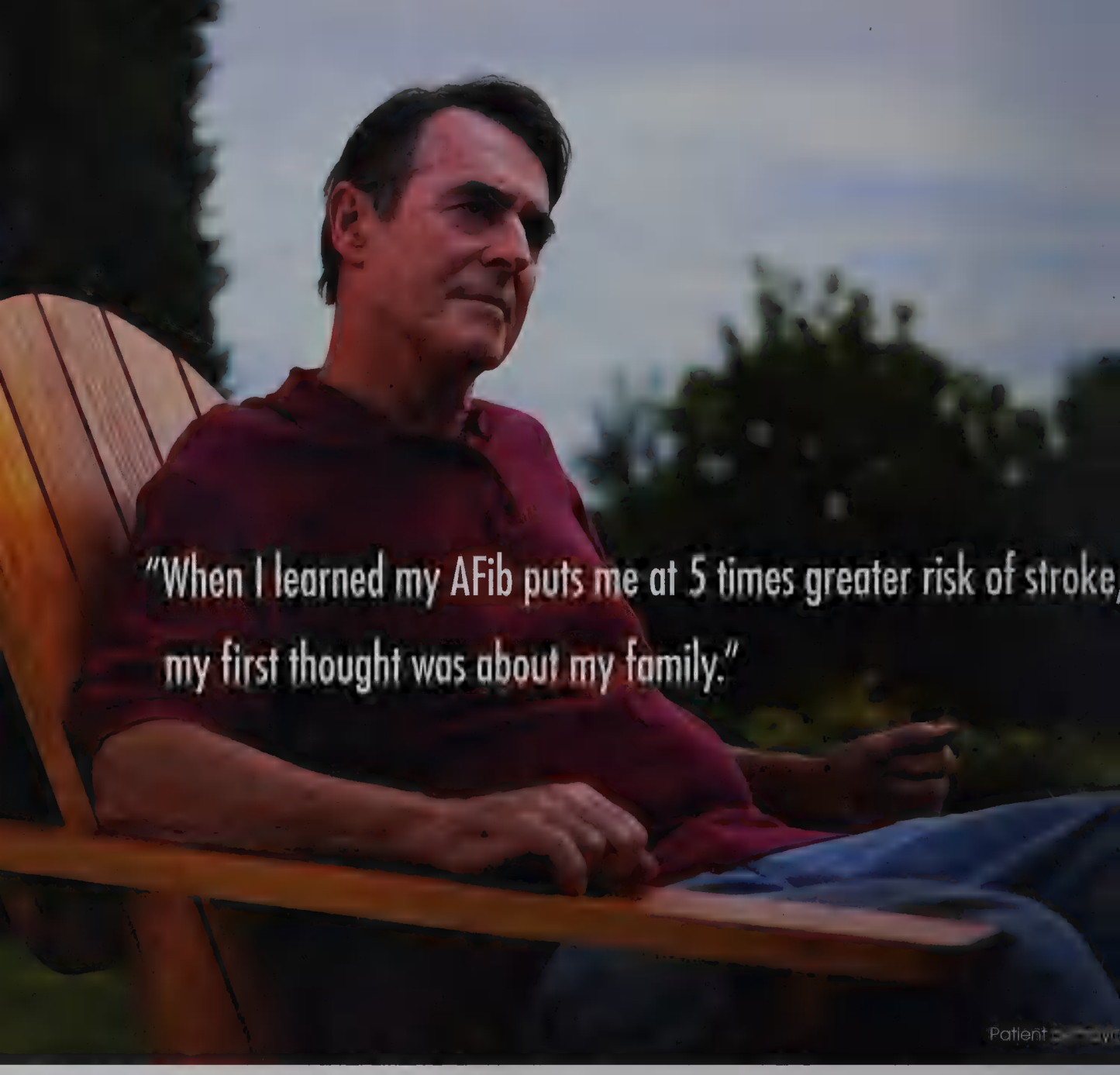
NIKON D7100 | 1/1250 SEC AT F/5.6 | ISO 400 | TANDEM FLASH

**India**
Trees infused with sunlight dwarf an early morning visitor to the rain forest on Havelock Island. Rajan, an Asian elephant retired from logging, takes the stroll as part of his daily routine and often enjoys a swim in the Andaman Sea.

**Order prints** of *National Geographic* photos online at **PrintsNGS.com**.

**China**
On his way to second place in a bee-wearing competition in Henan Province, a contestant disappears beneath a carpet of insects lured by a queen bee in a cage. A swain he will, standing upon tallied his total take: about 30 pounds of bees.

IMAGES




## What is Pradaxa® (dabigatran etexilate mesylate) capsules?

PRADAXA is a prescription blood-thinning medicine used to reduce the risk of stroke and blood clots in people with atrial fibrillation not caused by a heart valve problem.

## IMPORTANT SAFETY INFORMATION

PRADAXA can cause bleeding which can be serious and sometimes lead to death. Don't take PRADAXA if you currently have abnormal bleeding or if you have ever had an allergic reaction to it.

Boehringer Ingelheim

**Your risk of bleeding with PRADAXA may be higher if you:** are 75 years old or older, have kidney problems, have stomach or intestine bleeding that is recent or keeps coming back or you have a stomach ulcer, take other medicines that increase your risk of bleeding, like aspirin products, non-steroidal anti-inflammatory drugs (NSAIDs) and blood thinners, have kidney problems and take dronedarone (Multaq®) or ketoconazole tablets (Nizoral®).

**Call your doctor or seek immediate medical care if you have any of the following signs or symptoms of bleeding:** any unexpected, severe, or uncontrollable bleeding; or bleeding that lasts a long time, unusual or unexpected bruising, coughing up or vomiting blood; or vomit that looks like coffee grounds, pink or brown urine;

If you have an irregular heartbeat called atrial fibrillation, or AFib, not caused by a heart valve problem, **PRADAXA** can reduce your risk of stroke.

- In a clinical trial, PRADAXA **reduced stroke risk 35% more** than warfarin.

Risk reduction was greatest when compared to patients on warfarin whose blood tests showed lower levels of control.

- **Unlike warfarin:**

**No regular blood tests.**

**No dietary restrictions.**

*Ask your doctor about*

Pradaxa®
dabigatran etexilate
CAPSULES 150mg

red or black stools (looks like tar), unexpected pain, swelling, or joint pain, headaches and feeling dizzy or weak.

**It is important to tell your doctor about all medicines, vitamins and supplements you take. Some of your other medicines may affect the way PRADAXA works.**

**Take PRADAXA exactly as prescribed by your doctor. Don't stop taking PRADAXA without talking to your doctor as your risk of stroke may increase.**

Tell your doctor if you are planning to have **any** surgery, or medical or dental procedure, because you may have to stop taking PRADAXA for a short time.

PRADAXA can cause indigestion, stomach upset or burning, and stomach pain.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch or call 1-800-FDA-1088.

**Please see more detailed Medication Guide on next page.**

Pradaxa®
dabigatran etexilate
CAPSULES 150mg

*For more information or help paying for your medication, call 1-877-PRADAXA or visit pradaxa.com.*

PX235700CONS

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dabigatran etexilate
CAPSULES 150 mg

**MEDICATION GUIDE**
**PRADAXA (pra dax' a)**
**(dabigatran etexilate mesylate)**
**capsules**

Read this Medication Guide before you start taking PRADAXA and each time you get a refill. There may be new information. This Medication Guide does not take the place of talking with your doctor about your medical condition or your treatment.

**What is the most important information I should know about PRADAXA?**

- PRADAXA can cause bleeding which can be serious, and sometimes lead to death. This is because PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.
- **You may have a higher risk of bleeding if you take PRADAXA and:**
  - are over 75 years old
  - have kidney problems
  - have stomach or intestine bleeding that is recent or keeps coming back, or you have a stomach ulcer
  - take other medicines that increase your risk of bleeding, including:
    - aspirin or aspirin containing products
    - long-term (chronic) use of non-steroidal anti-inflammatory drugs (NSAIDs)
    - warfarin sodium (Coumadin®, Jantoven®)
    - a medicine that contains heparin
    - clopidogrel (Plavix®)
    - prasugrel (Effient®)
  - have certain kidney problems and also take the medicines dronedarone (Multaq®) or ketoconazole tablets (Nizoral®).

    Tell your doctor if you take any of these medicines. Ask your doctor or pharmacist if you are not sure if your medicine is one listed above.
- PRADAXA can increase your risk of bleeding because it lessens the ability of your blood to clot. While you take PRADAXA:
  - you may bruise more easily
  - it may take longer for any bleeding to stop.

**Call your doctor or get medical help right away if you have any of these signs or symptoms of bleeding:**

- unexpected bleeding or bleeding that lasts a long time, such as:
  - unusual bleeding from the gums
  - nose bleeds that happen often
  - menstrual bleeding or vaginal bleeding that is heavier than normal
- bleeding that is severe or you cannot control
- pink or brown urine
- red or black stools (looks like tar)
- bruises that happen without a known cause or get larger
- cough up blood or blood clots
- vomit blood or your vomit looks like "coffee grounds"
- unexpected pain, swelling, or joint pain
- headaches, feeling dizzy or weak

**Take PRADAXA exactly as prescribed. Do not stop taking PRADAXA without first talking to the doctor who prescribes it for you. Stopping PRADAXA may increase your risk of a stroke.**

PRADAXA may need to be stopped, if possible, for one or more days before any surgery, or medical or dental procedure. If you need to stop taking PRADAXA for **any reason**, talk to the doctor who prescribed PRADAXA for you to find out when you should stop taking it. Your doctor will tell you when to start taking PRADAXA again after your surgery or procedure.

**See "What are the possible side effects of PRADAXA?" for more information about side effects.**

**What is PRADAXA?**

PRADAXA is a prescription medicine used to reduce the risk of stroke and blood clots in people who have a medical condition called atrial fibrillation. With atrial fibrillation, part of the heart does not beat the way it should. This can lead to blood clots forming and increase your risk of a stroke. PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.

It is not known if PRADAXA is safe and works in children.

**Who should not take PRADAXA?**

**Do not take PRADAXA if you:**

- currently have certain types of abnormal bleeding. Talk to your doctor, before taking PRADAXA if you currently have unusual bleeding.
- have had a serious allergic reaction to PRADAXA. Ask your doctor if you are not sure.

**What should I tell my doctor before taking PRADAXA?**

Before you take PRADAXA, tell your doctor if you:

- have kidney problems
- have ever had bleeding problems
- have ever had stomach ulcers
- have any other medical condition

- are pregnant or plan to become pregnant. It is not known if PRADAXA will harm your unborn baby.
- are breastfeeding or plan to breastfeed. It is not known if PRADAXA passes into your breast milk.

Tell all of your doctors and dentists that you are taking PRADAXA. They should talk to the doctor who prescribed PRADAXA for you, before you have **any** surgery, or medical or dental procedure.

**Tell your doctor about all the medicines you take, including** prescription and non-prescription medicines, vitamins, and herbal supplements. Some of your other medicines may affect the way PRADAXA works. Certain medicines may increase your risk of bleeding. See "**What is the most important information I should know about PRADAXA**?"

Especially tell your doctor if you take:
- rifampin (Rifater, Rifamate, Rimactane, Rifadin)

Know the medicines you take. Keep a list of them and show it to your doctor and pharmacist when you get a new medicine.

**How should I take PRADAXA?**
- **Take PRADAXA exactly as prescribed by your doctor.**
- Do not take PRADAXA more often than your doctor tells you to.
- You can take PRADAXA with or without food.
- **PRADAXA comes in a bottle or in a blister package.**
- **Only open 1 bottle of PRADAXA at a time. Finish your opened bottle of PRADAXA before opening a new bottle.**
- **After opening a bottle of PRADAXA, use within 4 months. See "How should I store PRADAXA?"**
- **When it is time for you to take a dose of PRADAXA, only remove your prescribed dose of PRADAXA from your open bottle or blister package.**
- **Tightly close your bottle of PRADAXA right away after you take your dose.**
- Swallow PRADAXA capsules whole. Do not break, chew, or empty the pellets from the capsule.
- If you miss a dose of PRADAXA, take it as soon as you remember. If your next dose is less than 6 hours away, skip the missed dose. Do not take two doses of PRADAXA at the same time.
- Your doctor will decide how long you should take PRADAXA. **Do not stop taking PRADAXA without first talking with your doctor. Stopping PRADAXA may increase your risk of stroke.**
- Do not run out of PRADAXA. Refill your prescription before you run out. If you plan to have surgery, or a medical or a dental procedure, tell your doctor and dentist that you are taking PRADAXA. You may have to stop taking PRADAXA for a short time. See "What is the most important information I should know about PRADAXA?"
- If you take too much PRADAXA, go to the nearest hospital emergency room or call your doctor.
- Call your healthcare provider right away if you fall or injure yourself, especially if you hit your head. Your healthcare provider may need to check you.

**What are the possible side effects of PRADAXA?**
PRADAXA can cause serious side effects.
- See "What is the most important information I should know about PRADAXA?"
- Allergic Reactions. In some people, PRADAXA can cause symptoms of an allergic reaction, including hives, rash, and itching. Tell your doctor or get medical help right away if you get any of the following symptoms of a serious allergic reaction with PRADAXA:
  - chest pain or chest tightness
  - swelling of your face or tongue
  - trouble breathing or wheezing
  - feeling dizzy or faint

Common side effects of PRADAXA include:
- indigestion, upset stomach, or burning
- stomach pain

Tell your doctor if you have any side effect that bothers you or that does not go away.

These are not all of the possible side effects of PRADAXA. For more information, ask your doctor or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

**How should I store PRADAXA?**
- Store PRADAXA at room temperature between 59°F to 86°F (15°C to 30°C). After opening the bottle, use PRADAXA within 4 months. Safely throw away any unused PRADAXA after 4 months.
- **Keep PRADAXA in the original bottle or blister package to keep it dry (protect the capsules from moisture). Do not put PRADAXA in pill boxes or pill organizers.**
- **Tightly close your bottle of PRADAXA right away after you take your dose.**

**Keep PRADAXA and all medicines out of the reach of children.**

**General information about PRADAXA**
Medicines are sometimes prescribed for purposes other than those listed in a Medication Guide. Do not use PRADAXA for a condition for which it was not prescribed. Do not give your PRADAXA to other people, even if they have the same symptoms. It may harm them.

This Medication Guide summarizes the most important information about PRADAXA. If you would like more information, talk with your doctor. You can ask your pharmacist or doctor for information about PRADAXA that is written for health professionals.

For more information, go to www.PRADAXA.com or call 1-800-542-6257 or (TTY) 1-800-459-9906.

**What are the ingredients in PRADAXA?**

Active ingredient: dabigatran etexilate mesylate

Inactive ingredients: acacia, dimethicone, hypromellose, hydroxypropyl cellulose, talc, and tartaric acid. The capsule shell is composed of carrageenan, FD&C Blue No. 2 (150 mg strength only), FD&C Yellow No. 6, hypromellose, potassium chloride, titanium dioxide, and black edible ink.

This Medication Guide has been approved by the U.S. Food and Drug Administration.

**Distributed by:**
Boehringer Ingelheim Pharmaceuticals, Inc.
Ridgefield, CT 06877 USA

Revised: January 2012

Boehringer Ingelheim

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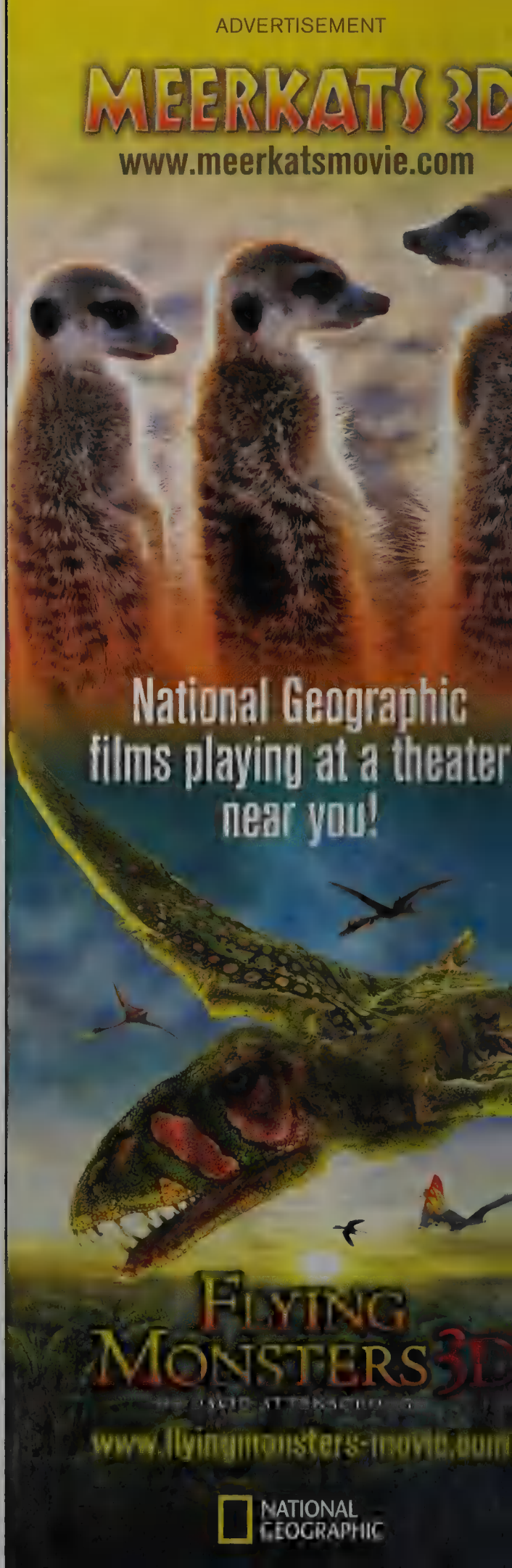

* On select language sets. Based on purchase of each level individually
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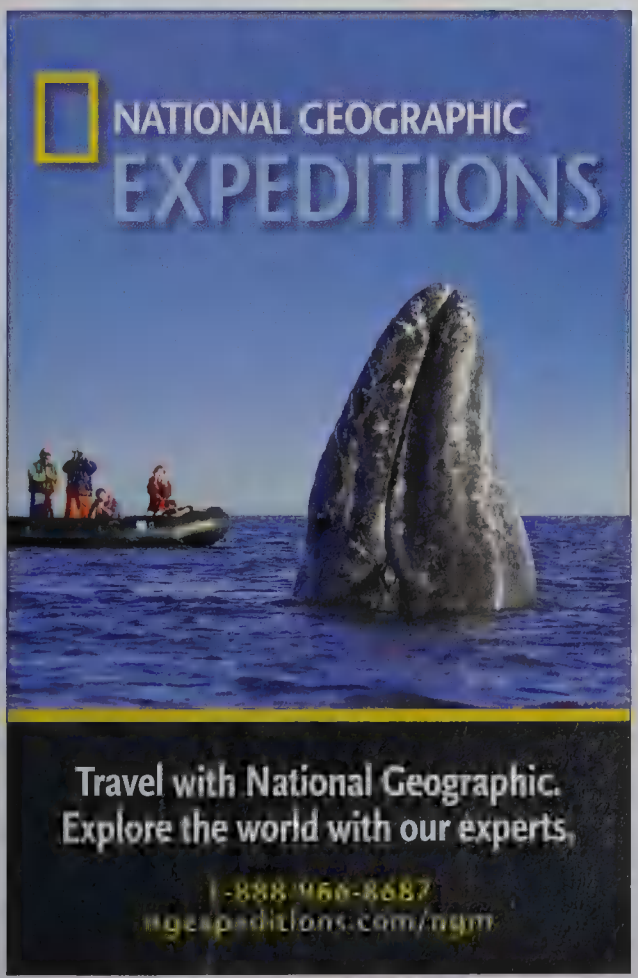


This page features two photographs: one chosen by our editors and one chosen by our readers via online voting. For more information, go to *ngm.com/yourshot.*

**EDITORS' CHOICE** **Wiesława Dąbrowska** Gdansk, Poland

To explore close-up photography, Dąbrowska, an art restorer, turned to small objects at home, like flowers, fruits, and vegetables. Here the inside of a red pepper reminded her of a woman's neck, adorned with a ruff collar and red dress.

**READERS' CHOICE**

**Marie-Pier Couture**
Quebec City, Canada

During a break from her job working with aerial photographs of cities, mining facilities, and forests around Canada, Couture, 30, visited one of her favorite animals at the zoo in St.-Félicien. She watched this polar bear drift lazily up and down in the water several times.

# NOW

## Remaking a British Icon

For decades the red telephone booth has been a much loved symbol of Britishness. The most popular model, the K6, was designed in 1935 by architect Sir Giles Gilbert Scott to commemorate King George V's silver jubilee and became an instant classic. Nearly 70,000 were installed throughout the U.K. Now, though, the glass-and-cast-iron kiosks are mainly gathering dust, thanks to mobile phones. Thousands have been removed, sold overseas as curios, and used as everything from movie props to outdoor showers.

Others are being "adopted" under a British Telecommunications program in which communities buy a decommissioned kiosk for one pound (about $1.60). Westbury-sub-Mendip in Somerset, for instance, now claims one of the world's smallest libraries, a refurbished booth with 150 books and DVDs. Villagers in Settle, North Yorkshire, made theirs an art gallery—former Queen guitarist Brian May exhibited there—for a touch of "bohemian rhapsody" on the green. —*Rolf Smith*

*In a storage lot in England, decommissioned K6 telephone booths await refurbishment.*

*Sri Lanka tops the list of nations with a thriving bycatch problem. Juveniles here at a bustling Negombo market and similar Indian, Peruvian, Indonesian, and Chinese ones round out the top five.*

# Manta and mobula ray numbers are falling as they're hunted for Asian remedies.

**RAYS IN DANGER** | In the ocean, manta and mobula rays move with exceptional grace, gliding and twirling with mouths agape to feed near the surface. Now an appetite for their gill rakers—filaments that filter out plankton, krill, and other food—has put their populations at risk, says a new study. Demand in China for dried gill rakers as purported medicine for chicken pox and other ailments means a large manta can fetch several hundred dollars, versus $20 to $40 for its meat alone. Last year around 100,000 of the rays landed in global fish markets, the study estimates, boding ill for nearly a dozen mobulid species—many listed by the IUCN as vulnerable or near threatened.

"As quickly as rays started appearing in markets, we fear they could disappear from the sea just as quickly," says Shawn Heinrichs, lead author of the report released by conservation groups WildAid and Shark Savers. Mobulid catches rose sharply about a decade ago. Despite increased fishing efforts, fewer and smaller rays are being caught, indicating populations in peril, says Heinrichs. On the flip side, the sublime creatures have proved a lucrative tourist draw—a ray of hope for the slow-to-reproduce sea dwellers. *—Luna Shyr*

PHOTO: THOMAS P. PESCH

# Go green without going slow.

Driving a fuel-efficient* car shouldn't mean sacrificing performance. It's this belief that drove us to develop the TDI® Clean Diesel engine and a turbocharged hybrid. Both help maximize driving dynamics while helping minimize environmental impact. And we've expanded that thinking beyond cars to everything we do: from the first LEED® Platinum-certified automotive plant to working with the Surfrider Foundation to protect our oceans. It's called thinking blue and it's how we're thinking beyond green. **That's the Power of German Engineering.**

Think Blue.

Das Auto.

vw.com/thinkblue

*See www.fueleconomy.gov for EPA estimates. Your mileage will vary. ©2012 Volkswagen of America, Inc.

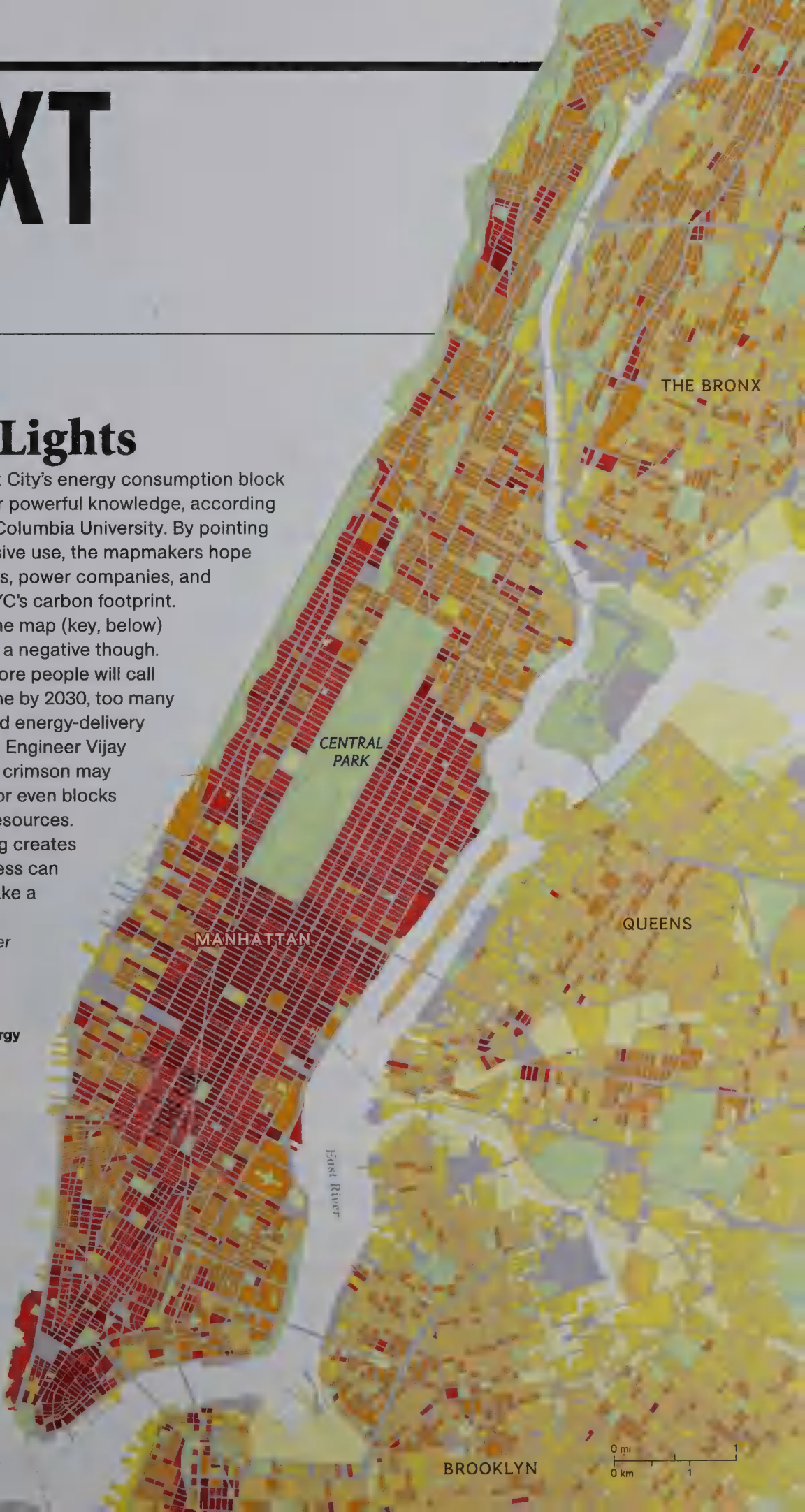
# NEXT

CITY SOLUTIONS

## City of Lights

Charting New York City's energy consumption block by block makes for powerful knowledge, according to researchers at Columbia University. By pointing out areas of intensive use, the mapmakers hope to help city officials, power companies, and landlords lower NYC's carbon footprint.

Seeing red on the map (key, below) doesn't have to be a negative though. Almost a million more people will call New York City home by 2030, too many for the town's dated energy-delivery systems to handle. Engineer Vijay Modi says that the crimson may point to buildings or even blocks that could share resources. Powering a building creates heat, and that excess can be siphoned to make a neighbor's shower hot. *—Bruce Falconer*




**Estimated annual energy consumption, 2009**
(kWh per square meter of block area)

- 2,500 and greater
- 1,250-2,499
- 600-1,249
- 300-599
- 100-299
- 1-99
- No data
- Open space

A 100-watt lightbulb turned on for ten hours uses one kilowatt-hour (kWh) of energy.

JEROME N. COOKSON, NGM STAFF

SOURCES: COLUMBIA ENGINEERING AND EARTH INSTITUTE; NYC DEPARTMENT OF INFORMATION TECHNOLOGY AND TELECOMMUNICATIONS

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If you have type 2 diabetes you still have a chance to control your blood sugar for yourself and those who depend on you most. Reducing your blood sugar can help reduce the risk of diabetes complications such as blindness, kidney disease, nerve damage and other serious health problems. If pills, diet and exercise aren't enough, insulin is the most effective way to reduce your blood sugar. And today insulin comes in easy-to-use pens.

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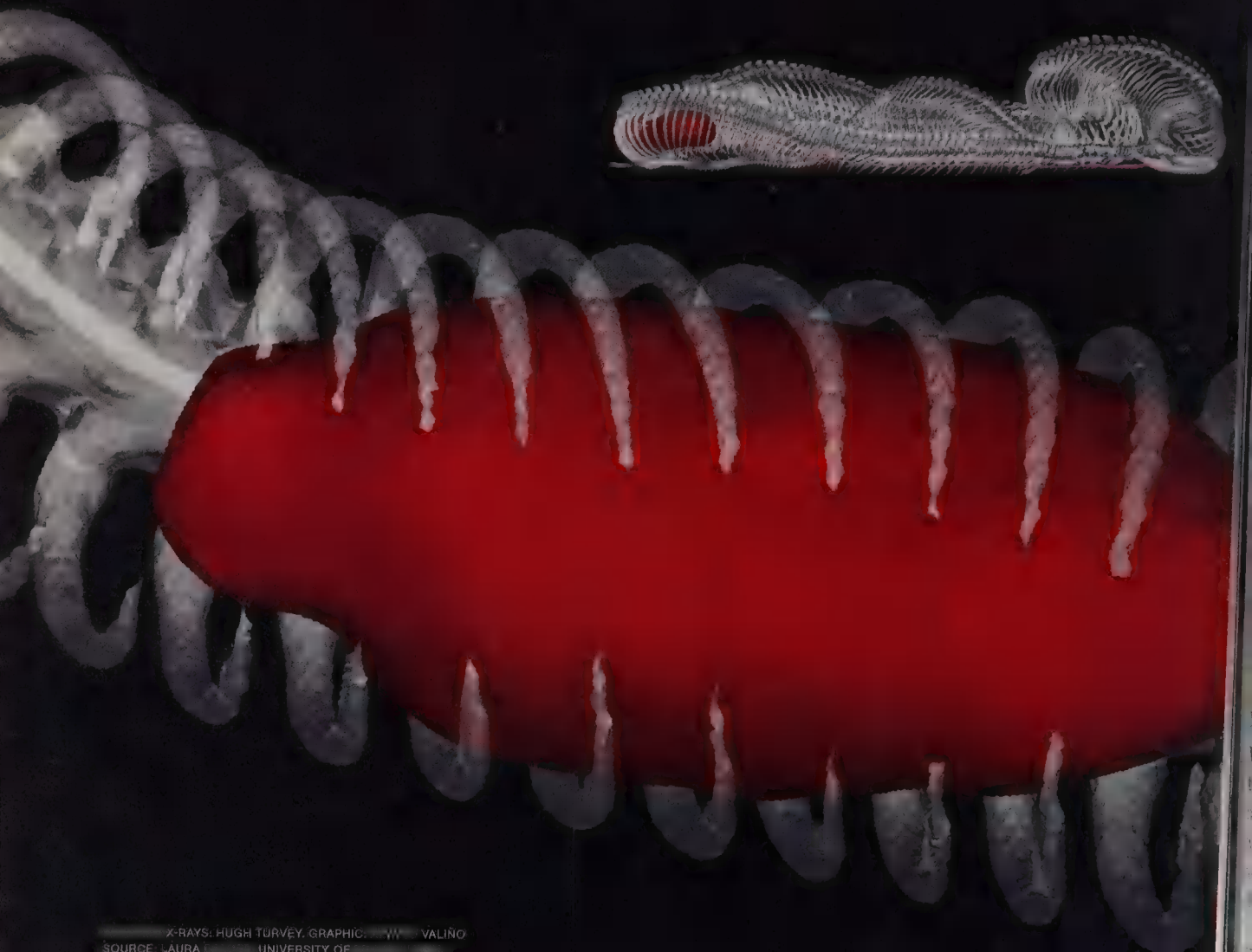
# Gross Anatomy

Biologist Leslie Leinwand found Burmese pythons to be bighearted, at least when they eat. In fact, with the exception of the brain (likely constrained by the skull), all of the snake's organs studied grew between 30 and 100 percent after a meal. Portion size matters. Leinwand says, "The organs will just keep getting bigger and bigger as the meal does." And when the pythons do least—it may be months or even a year between meals—reaction time is relatively fast. Organs start to grow at 12 hours and reach maximum size by 76 hours, shrinking back to normal in ten days, digestion done. The suite of enlarged organs, anchored by the heart, accommodates a metabolic rate 40 times normal. "It's like a thoroughbred running the Kentucky Derby, except for days on end," says Leinwand.

The python is building new tissue, not swelling up—a feat that Leinwand thinks might translate to treating heart disease in humans. Her team hopes the three-lipid combo that triggers the cardiac cell growth may combat heart atrophy in cancer patients and astronauts. Or, conversely, that disease-enlarged hearts might mimic the python ticker's regression phase and go down a size. —*Johnna Rizzo*

*X-rays of a Burmese python (below) expose the 40 percent increase of its heart after a meal, which can equal 25 percent of its body mass.*



X-RAYS: HUGH TURVEY. GRAPHIC: [illegible] VALIÑO
SOURCE: LAURA [illegible] UNIVERSITY OF

Analog and digital display
Stop watch function
Built-in alarm
LCD complications
Electro-luminescent backlight
Suggested Retail $395... NOW, on your wrist for $29.95 For a limited Time Only

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***The new face of time? Stauer's Compendium Hybrid fuses form and functionality for UNDER $30! Read on...***

Innovation is the path to the future. Stauer takes that seriously. That's why we developed the ***Compendium Hybrid***, a stunningly-designed hybrid chronograph with over one dozen analog and digital functions that is more versatile than any watch that we have ever engineered.

New technology usually starts out at astronomical prices and then comes down years later. We skipped that step to allow everyone the chance to experience this watch's brilliant fusion of technology and style. We originally priced the Stauer ***Compendium Hybrid*** at $395 based on the market for advanced sports watches... but then stopped ourselves. Since this is no ordinary economy, we decided to start at 92% off from day one. That means this new technological marvel can be yours for only $29!

**Welcome a new Digital Revolution.** With the release of the dynamic new ***Compendium***, those boxy, plastic wrist calculators of the past have been replaced by this luxurious LCD chronograph that is sophisticated enough for a formal evening out, but rugged and tough enough to feel at home in a cockpit, camping expedition or covert mission.

The watch's extraordinary dial seamlessly blends an analog watch face with a stylish digital display. Three superbright luminous hands keep time along the inner dial, while a trio of circular LCD windows track the hour, minutes and seconds. An eye-catching digital semi-circle animates in time with the second hand and shows the day of the week. The watch also features a rotating bezel, stopwatch and alarm functions and green, electro-luminescence backlight. The ***Compendium Hybrid*** secures with a rugged stainless steel band and is water-resistant to 3 ATMs.

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WATCH SPECS: - Three LCD windows show hour, minute and second
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**Your satisfaction is guaranteed.** Bring home the Helenite Necklace and see for yourself. If you are not completely blown away by the rare beauty of this exceptional stone, simply return the necklace within 30 days for a full refund of your purchase price.

**Helenite Necklace** (6 ½ ctw)—~~$249~~ **$129**

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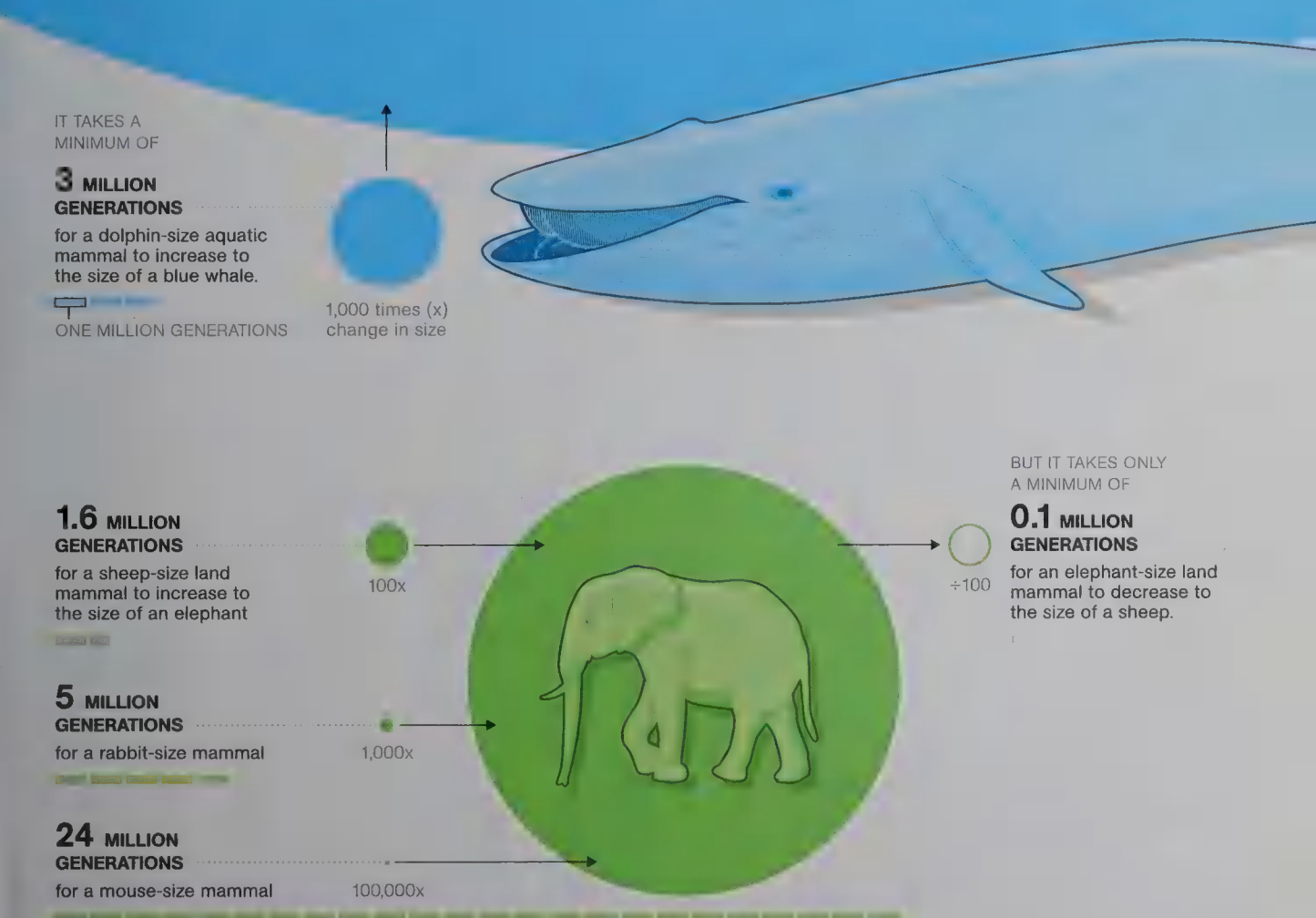
*Smart Luxuries—Surprising Prices*

**Sizing Up** Seventy million years ago the largest known mammal weighed only six pounds. From then, some animals grew steadily. But slowly. Large-scale changes in body size actually took millions of generations.

So say scientists led by Alistair Evans of Australia's Monash University, who studied fossil records of 28 groups of mammals, including elephants, primates, and whales. The team is the first to get hard numbers on just how long it takes to get a lot bigger. After all, gaining girth isn't just about adding muscle and bone. It's also about reengineering hearts and eyes—even metabolism and diet. And limbs need to carry more weight, which may explain another revelation: Whales can grow twice as fast, likely because water helps support newly added mass. Evans adds that evolving larger takes ten times as long as evolving smaller, reaffirming just how much sheer size is to be prized. *—Gretchen Parker*


IT TAKES A MINIMUM OF
3 MILLION GENERATIONS
for a dolphin-size aquatic mammal to increase to the size of a blue whale.
ONE MILLION GENERATIONS
1,000 times (x) change in size
1.6 MILLION GENERATIONS
for a sheep-size land mammal to increase to the size of an elephant
100x
5 MILLION GENERATIONS
for a rabbit-size mammal
1,000x
24 MILLION GENERATIONS
for a mouse-size mammal
100,000x
BUT IT TAKES ONLY A MINIMUM OF
0.1 MILLION GENERATIONS
for an elephant-size land mammal to decrease to the size of a sheep.
÷100

Prostate cancer is discovered in a **2,200-YEAR-OLD MUMMY** in his 50s—the second oldest known case and further evidence for a genetic link for the disease. ▪ **CHICKPEAS AND FAVA BEANS** from Syria are among the 25,000 samples recently added to the Arctic seed vault. ▪ **MADAGASCAR** was first settled 1,200 years ago by 30 women from Indonesia, say researchers from Massey University. ▪ The French government ordered a phaseout of **"MADEMOISELLE"** to identify unmarried women on official forms.

GRAPHIC: SIWEN LI. SOURCE: ALISTAIR EVANS, MONASH UNIVERSITY, AUSTRALIA

# IN THE SHADOW OF WOUNDED KNEE

*After 150 years of broken promises, the Oglala Lakota people of the Pine Ridge Reservation in South Dakota are nurturing their tribal customs, language, and beliefs. A rare, intimate portrait shows their resilience in the face of hardship.*

Riders take a break during a day of activities to mark the 1876 defeat of Lt. Col. George Armstrong Custer.

Stanley Good Voice Elk, a *heyoka*, burns sage to ritually purify his surroundings. In Oglala spirituality, heyokas are recipients of sacred visions who employ clownish speech and behavior to provoke spiritual awareness and "keep balance," says Good Voice Elk. Through his mask, he channels the power of an inherited spirit, which transforms him into Spider Respects Nothing.

Three-year-old C. J. Shot bathes among dishes. The Oglala concept of *tiospaye*—the unity of the extended family—means that homes are often overcrowded, especially with the severe housing shortage on the

reservation. In 2008, when this photograph was made, 22 people lived in the three-bedroom house. "These houses aren't who we are," says Oglala activist Alex White Plume.

BY ALEXANDRA FULLER

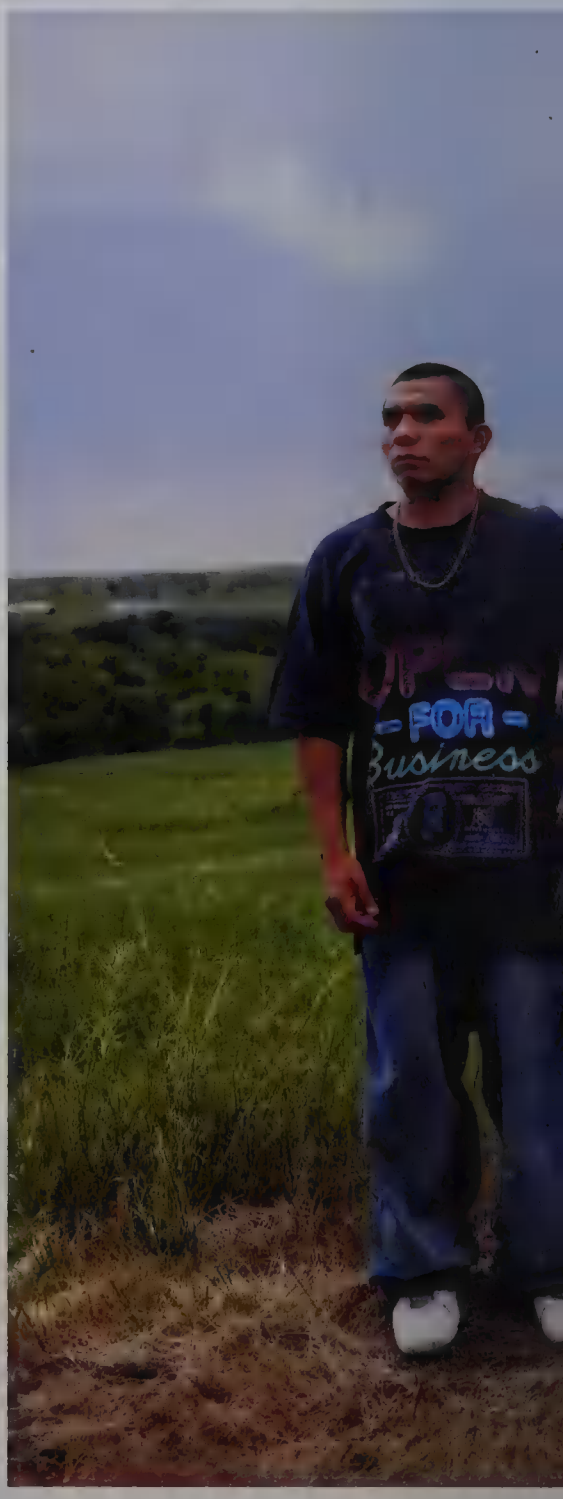
PHOTOGRAPHS BY
AARON HUEY

ALMOST EVERY HISTORICAL atrocity has a geographically symbolic core, a place whose name conjures up the trauma of a whole people: Auschwitz, Robben Island, Nanjing. For the Oglala Lakota of the Pine Ridge Indian Reservation that place is a site near Wounded Knee Creek, 16 miles northeast of the town of Pine Ridge.

From a distance the hill is unremarkable, another picturesque tree-spotted mound in the creased prairie. But here at the mass grave of all those who were killed on a winter morning more than a century ago, it's easy to believe that certain energies—acts of tremendous violence and of transcendent love—hang in the air forever and possess a forever half-life.

Alex White Plume, a 60-year-old Oglala Lakota activist, lives with his family and extended family on a 2,000-acre ranch near Wounded Knee Creek. White Plume's land is lovely beyond any singing, rolling out from sage-covered knolls to creeks bruised with late summer lushness. From certain aspects, you can see the Badlands, all sun-bleached spires and scoured pinnacles. And looking another way, you can see the horizon-crowning darkness of the Black Hills of South Dakota.

One hot and humid day in early August,



NGM MAPS

Oglala youths hold an upside-down flag—an international symbol of distress and an act of defiance toward the U.S. government—at a rally to commemorate a 1975 shoot-out between American Indian Movement (AIM) activists and FBI agents. Two agents and one AIM member died; AIM's Leonard Peltier was jailed for life.

THE OGLALA SIOUX TRIBE OF PINE RIDGE CALL THEMSELVES THE OGLALA LAKOTA. (THEIR FLAG IS OPPOSITE, TOP.) THEY ARE ONE OF SEVERAL GROUPS THAT MAKE UP THE SIOUX NATION. "SIOUX" COMES FROM THE NAME USED FOR THEM BY THEIR ALGONQUIAN-SPEAKING ENEMIES AND ADAPTED BY FRENCH TRADERS.

I drove out to interview White Plume in a screened outdoor kitchen he had just built for his wife. Hemp plants sprouted thickly all over their garden. "Go ahead and smoke as much as you like," White Plume offered. "I always tell people that: Smoke as much as you want, but you won't get very high." The plants are remnants from a plantation of industrial hemp—low-tetrahydrocannabinol (THC) *Cannabis sativa*—cultivated by the White Plume family in 2000.

**$9,728***
**Annual per capita income, PINE RIDGE RESERVATION (RES.)**
**$27,334 UNITED STATES**

**48.3%**
**Poverty rate, PINE RIDGE RES.**
**13.8% UNITED STATES**

During World War II cultivation of hemp was encouraged in the United States, its fiber used for rope, canvas, and uniforms. But in 1970 low-THC industrial hemp was outlawed under the Controlled Substances Act. In 1998 the Oglala Sioux Tribe passed an ordinance allowing the cultivation of low-THC hemp, a crop well suited to places, like the "rez," with a short growing season, arid soil, and weather fluctuations.

"The people of Pine Ridge have sovereign status as an independent nation," White Plume said. "I take that to mean I am free to make a living from this land." So in spite of reportedly stern warnings from Robert Ecoffey, the superintendent for the Bureau of Indian Affairs (BIA) on Pine Ridge, who pointed out that Oglala Sioux sovereignty is limited and does not include the right to violate federal laws, the White Plumes planted an acre and a half of industrial hemp using seeds collected from plants growing wild on the rez. A few days before the crop was due to be harvested, in late August 2000, agents from the Drug Enforcement Administration, the FBI, the BIA, and the U.S. Marshals Service swarmed the place in helicopters and SUVs and shut down the hemp operation. The crop went feral. "It was an experiment in capitalism and a test of our sovereignty, but it seems the U.S. government doesn't want to admit that we should have either," White Plume said. Then he laughed in the way of a man who knows that he cannot be defeated by ordinary disappointments.

After that we spoke of the treaties made and broken between the U.S. and the Sioux, and that led naturally to a conversation about the Black Hills, which the Oglala consider their *axis mundi,* the center of their spiritual world. The 1868 Fort Laramie Treaty guaranteed the Sioux possession of the hills, but after gold was discovered there in 1874, prospectors swarmed in, and the U.S. government quickly seized the land. The Sioux refused to accept the legitimacy of the seizure and fought the takeover for more than a century. On June 30, 1980, in *United States* v. *Sioux Nation of Indians,* the U.S. Supreme Court upheld an award of $17.5 million for the value of the land in 1877, along with 103 years' worth of interest, together totaling $106 million. But the Sioux rejected the payment, insisting that the Black Hills would never be for sale.

And then White Plume asked me to consider the seemingly calculated insult of Mount Rushmore. "The leaders of the people who have broken every treaty with my people have their faces carved into our most holy place. What is the equivalent? Do you have an equivalent?" I could offer none. Then White Plume, who punctuates his oddly unexcited view of history's injustices not only with laughter but also with pauses long enough to roll a cigarette, looked up and asked if I had extra time on my hands and extra fuel in my car.

I SAID I HAD BOTH, and we drove out onto his cathedral land. Sitting by a cottonwood-lined creek, in a dark pool of shade, we spoke of the ways in which lives are lost on the rez and about the suicide, earlier that summer, of a 15-year-old Oglala Lakota girl. Partly because time is not linear for the Oglala Lakota but rather is expressed in circular endlessness and beginnings, and partly because many can recite the members of their family trees, branch after branch, twig after twig, vines and incidental outgrowths

---

*Alexandra Fuller wrote in June 2010 about reconciliation in South Africa. Aaron Huey spent seven years documenting life on Pine Ridge Reservation.*

*MOST RECENT STATISTICS AVAILABLE, 2005-10. SOURCES: U.S. CENSUS BUREAU; U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES; SOUTH DAKOTA DEPARTMENT OF HEALTH

# WHEN I WAS A BOY
# THE SIOUX OWNED THE WORLD.

The sun rose and set in their lands.

They sent 10,000 horsemen to battle.

Where are the warriors to-day? Who slew them?

Where are our lands? Who owns them?

*Sitting Bull, circa 1831–1890*

included, it does not seem to me too big a historical step to go from the bodies piled in the snow at Wounded Knee in 1890 to the body of Dusti Rose Jumping Eagle lying in shiny mannequin perfection in an open coffin in a tepee in Billy Mills Hall in the town of Pine Ridge in early July 2011, a scarf draped over her neck to conceal the manner of her suicide.

"The whole Sioux Nation was wounded at that last terrible massacre, and we've been suffering ever since. It's true we have our own ways of healing ourselves from the genocidal wound, but there is just so much historical trauma, so much pain, so much death," White Plume said, and he would know. There is a flat plateau in the center of his ranch, he told me, where some of the historic Ghost Dances that precipitated the Wounded Knee massacre are supposed to have taken place. Participants in these ritualized spiritual ceremonies danced themselves into an altered state and claimed to have communed easily with their dead, become mentally untethered from the Earth, and touched the morning star. Then there is the unavoidable fact that three of his relatives were killed on that winter day.

In 1890 a bad drought brought more than the usual deprivation to the reduced reservations of the Great Plains. (The Great Sioux Reservation had been chopped up into six smaller reservations.) At the same time, agents of the BIA got jumpy about an upswing in the number of Ghost Dances being performed by the Sioux, who were gathering with increasing desperation and frequency on the open prairie, petitioning for advice and guidance from their ancestors and spirits.

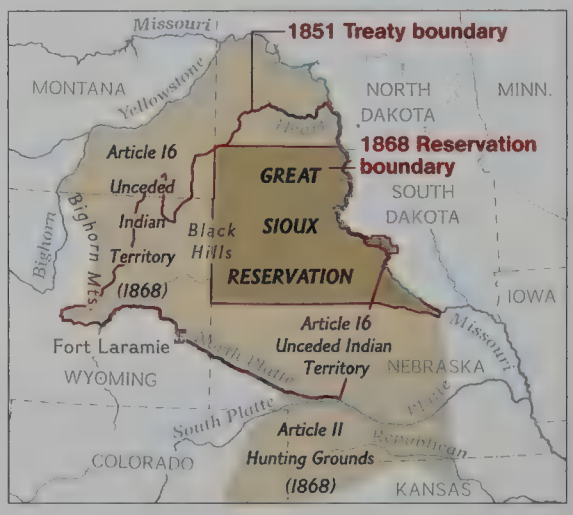
On December 15, 1890, U.S. Indian policemen arrested Sitting Bull in an effort to quell the "messiah craze" of the native ceremonies. The arrest turned unintentionally violent in ways that retrospectively seem inevitable. Sitting Bull was killed, along with seven of his supporters and six of the policemen. Fearing a backlash, another leader, Big Foot, fled south with his band under cover of night to seek asylum with Red Cloud on the Pine Ridge Reservation.

Nearly two weeks later, on the morning of December 28, 1890, a nervy U.S. Seventh Cavalry unit found Big Foot's band at Porcupine Creek and escorted them to Wounded Knee Creek. The following morning the cavalry attempted to disarm the Indians. What happened next on that frozen-prairie morning isn't entirely clear. It is said that a medicine man, Yellow Bird, began to perform a dance, throwing handfuls of dirt in the air. A scuffle ensued, a gun was discharged, the Army opened fire, and by the time the smoke cleared, Big Foot and at least 145 members of his band had been killed (the Oglala argue many more), including 84 men and boys, 44 women, and 18 children. A reported 25 U.S. soldiers also died, some possibly as a *(Continued on page 48)*

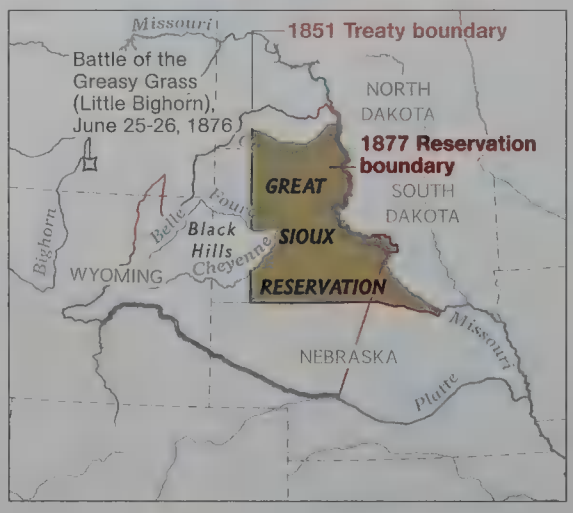
Bareback riders Carey Rouillard (left) and Travis New Holy stop for a neighborly chat in Evergreen. Oglala have a traditional reverence for the horse, which they call *sunka wakan,* or sacred dog. Evergreen, one resident says, is "a good community. Everybody gets along. Neighbors help out neighbors."

# THE LOST LAND

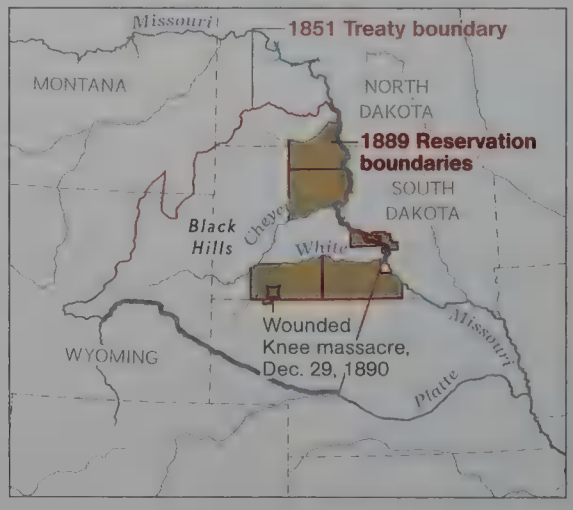
Around 1700, Sioux tribes on the prairies of western Minnesota hunted buffalo on foot. By the mid-1700s various tribes had gained access to horses, and by the turn of the 19th century the Oglala Sioux and other Plains Indians had developed a way of life that depended on mounted buffalo hunting. After gold was found in California in 1849 and in the Black Hills in 1874, prospectors, merchants, and settlers streamed into Sioux territory. The culture clash led to a series of broken treaties and unfavorable legislation, which confined the tribes to an ever shrinking area (maps, right). Meanwhile, the newcomers had all but exterminated the buffalo. In 1980 the Supreme Court ordered the U.S. government to pay for its appropriation of the Black Hills. With interest, the amount is now more than a billion dollars, but the Sioux won't touch it. They want their land back.




**1851-1868**
Treaties with the United States first established the Sioux Nation's boundaries and then set up a reservation. An 1868 treaty allowed hunting in unceded territory as long as buffalo herds roamed there.




**1876-1877**
The U.S. Army fought the Sioux who remained outside the reservation. Colonel Custer's troops were annihilated at Little Bighorn. The government then seized the Black Hills and other Sioux land.



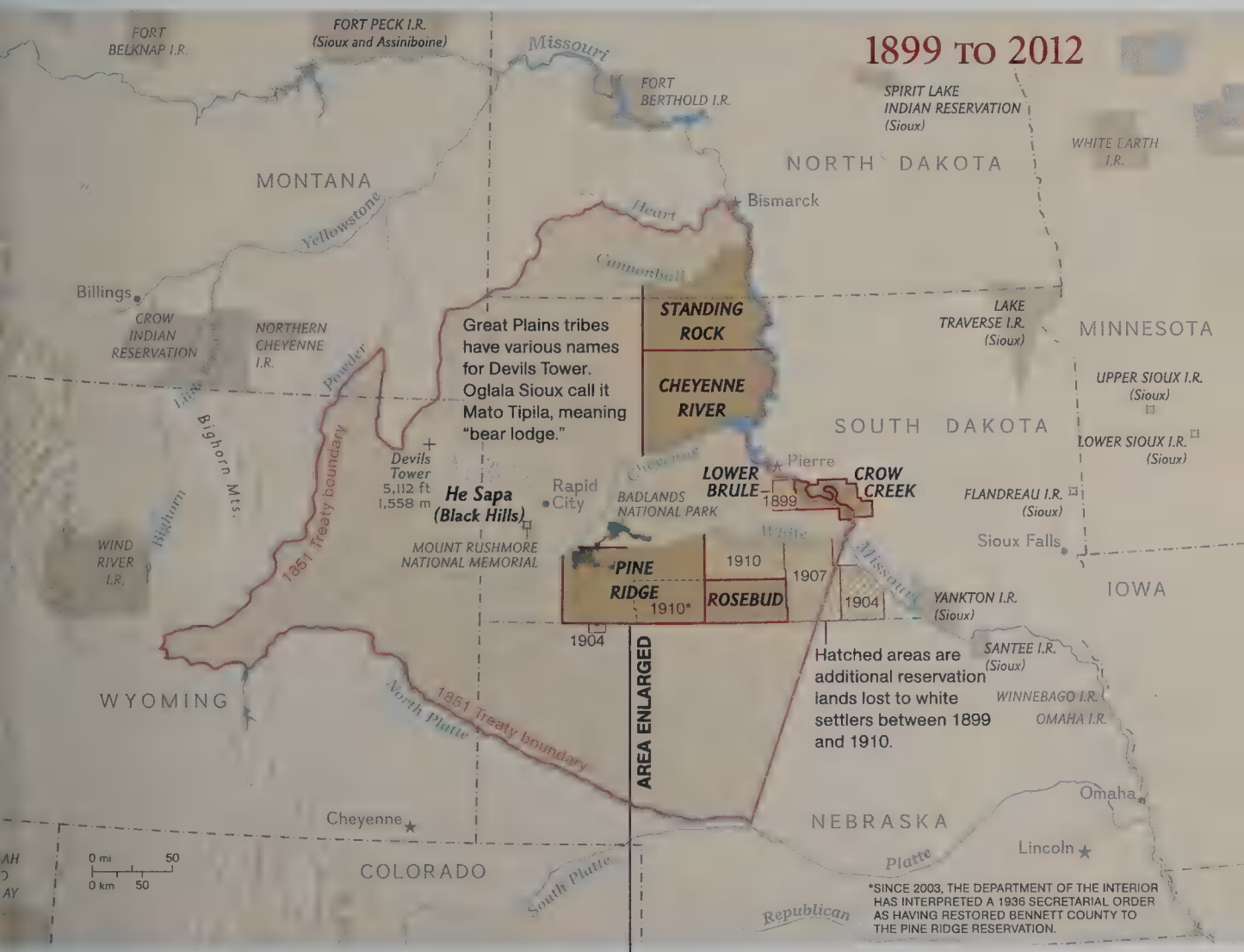

**1889**
As North and South Dakota moved toward statehood, the 21-million-acre reservation was cut by half and the remaining land divided into six smaller reservations. Some of that reservation land was later opened to settlers.

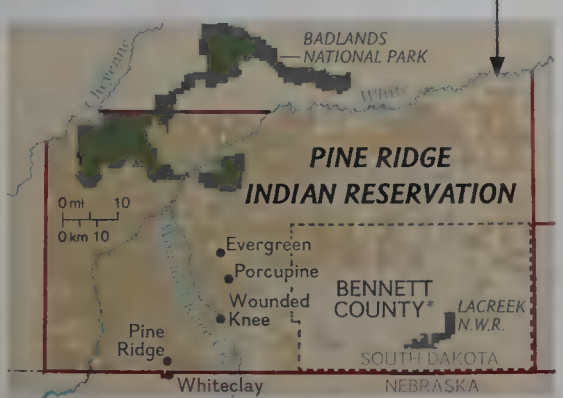
0 mi 100
0 km 100

PRESENT BOUNDARIES AND DRAINAGE SHOWN

MARTIN GAMACHE, NGM STAFF

SOURCES: DAVID BARTECCHI, VILLAGE EARTH; BUREAU OF INDIAN AFFAIRS; U.S. CENSUS BUREAU; RICHMOND CLOW, UNIVERSITY OF MONTANA; RAYMOND J. DEMALLIE, INDIANA UNIVERSITY; U.S. DEPT. OF THE INTERIOR; LIBRARY OF CONGRESS; MARGARET PEARCE, UNIVERSITY OF KANSAS




Land owned by Indians within the reservation as of 2007

**Today**

On Pine Ridge and five other reservations (above), the Sioux own five million acres of their original treaty land. Through the Bureau of Indian Affairs, tribes can arrange leases of reservation land, used mainly for grazing. Some leases go to Indians, others to outsiders. Because of the way land was originally allotted, the Sioux have been left with the least productive tracts.

Teenagers disregard the threat of a summer storm in the town of Wounded Knee. On December 29, 1890, at least 146 Indians were killed by the U.S. Army near here. For the Sioux and other Native Americans, Wounded Knee remains a potent symbol—geographically and politically—of historic injustice.

A passenger barely has room for the journey home as a car is loaded with used clothing donated by a Colorado-based Native American charity. Contrary to popular myth, Native Americans do not automatically

receive a monthly federal check and are not exempt from taxes. The Oglala Lakota and other Sioux tribes have refused a monetary settlement for the U.S.'s illegal seizure of the Black Hills, their spiritual home.

(Continued from page 39) result of friendly fire.

Testifying to the commissioner of Indian Affairs in February 1891, the Oglala leader American Horse said of that day, "There was a woman with an infant in her arms who was killed as she almost touched the flag of truce... Right near the flag of truce a mother was shot down with her infant; the child not knowing that its mother was dead was still nursing, and that was especially a very sad sight... Of course it would have been all right if only the men were killed; we would feel almost grateful for it. But the fact of the killing of the women, and more especially the killing of the young boys and girls who are to go to make up the future strength of the Indian people, is the saddest part of the whole affair and we feel it very sorely."

**66.6**
**Life expectancy, PINE RIDGE RES. (Shannon County)**
**76.5 UNITED STATES**

**18.4**
**Infant mortality per 1,000 births, PINE RIDGE RES. (Shannon County)**
**6.8 UNITED STATES**

"THEY TRIED EXTERMINATION, they tried assimilation, they broke every single treaty they ever made with us," White Plume said. "They took away our horses. They outlawed our language. Our ceremonies were forbidden." White Plume is insistent about the depth and breadth of the policies and laws by which the U.S. government sought to quash Native Americans, but his delivery is uncomplainingly matter-of-fact. "Our holy leaders had to go underground for nearly a century." It wasn't until Congress passed the American Indian Religious Freedom Act, in 1978, that any interference in native spiritual practices was made a crime. "And yet our ceremonies survived, our language survived," White Plume said.

Buried deep within the pages of the 2010 Defense appropriations bill, signed by President Barack Obama in December 2009, is an official apology "to all Native Peoples for the many instances of violence, maltreatment, and neglect inflicted on Native Peoples by citizens of the United States." The resolution commends those states "that have begun reconciliation efforts with recognized Indian tribes," but there is no mention of reparations, nor of honoring long-broken treaties.

White Plume lit one of his rolled-up cigarettes and squinted at me through a ribbon of smoke. "Do you know what saved me from becoming a cold-blooded murderer? My language saved me. There is no way for me to be hateful in my language. It's such a beautiful, gentle language. It's so peaceful." Then White Plume started to speak in Lakota, and there was no denying the words came softly.

Above us, in an otherwise empty sky, two small clouds touched each other and melted into nothing. White Plume got up and walked toward the creek, and then I heard him exclaim in surprise—"Aha!"—as if greeting someone revered, and deeply known. He had found the cottonwood tree for his Sun Dance ceremony. Although most Pine Ridge traditions are off-limits to outsiders, I gathered that the following would occur: The tree would be brought down by White Plume and some of the men in his family and carried to the Sun Dance grounds with the kind of reverence due a holy being. There it would be fixed with prayer ties—bundles of tobacco and other offerings wrapped with cloth of various colors—and set in a hole in the ground, where it would remain until the following year.

In 1974 White Plume joined the Army and was deployed to Germany. (Native Americans are disproportionately represented in the armed forces.) "The year I left to join the Army, there were only three Sun Dances on the whole reservation," he said. "Now there are scores." White Plume still holds his own family and extended family's Sun Dances in the traditional way. "It's just us," he said, in a way that sounded less exclusive than it looks in print. "It's so beautiful, so spiritual."

The vigorous resurgence of Sun Dance ceremonies owes much to the passage of the 1978 act but also to the widespread Indian activism that began earnestly in the early 1970s. Now every year during the summer there are more than 50 separate Sun Dances across Pine Ridge, up from the few held in secret decades ago. At each

WE PREFERRED HUNTING
to a life of idleness on the reservation,
where we were driven against our will…
We preferred our own way of living…
All we wanted was peace
and to be left alone.

*Crazy Horse, ca 1842–1877*

ceremony scores of invited participants dance, meditate, pray, are purified in sweat lodges, and fast for days at a time. Men who are deemed spiritually equipped to withstand this symbolic act of communal self-sacrifice are pierced with bone pegs at the end of ropes tied to the branches of ritually harvested cottonwood trees. They then jerk themselves free, tearing their skin in the process. A mantle of ancient-feeling, sacred humidity settles over the rez.

IT SAYS A LOT of what you need to know about Alex White Plume that an imperfect yet contagiously optimistic 38-year-old woman named Olowan Thunder Hawk Martinez considers him a mentor. At one time or another, Martinez has been almost everything you might despair of in a person, but she is also an irrepressible spirit and a courageously outspoken, self-appointed youth leader. "You want me to be that drunk Indian woman in the corner?" Like her mentor, Martinez has an unsettling habit of laughing when she is most serious. She laughed now. "I've been there, done that. I snapped out of it."

On the night she heard of Jumping Eagle's suicide, Martinez said, she could feel the victim's pain—as if the body of the dying girl had briefly broken its bounds and inhabited her own. "I know why a lot of young girls try to kill themselves on the rez," Martinez said. "We're all in constant danger of losing ourselves, losing our identities. It's a daily struggle for each and every one of us to be fully Lakota. And sometimes we lose the struggle, and then the men take out their feeling of worthlessness on the women, the women take out their feelings of worthlessness on themselves, and everyone takes out their feelings of worthlessness on the children."

In Martinez's case, an uncle had molested her when she was six and again when she was ten. "Afterward he used words—he told me I was useless. I remember feeling such a deep pain that nothing and nobody could reach inside to take it away." Soon after the second defilement Martinez found herself standing alone in the kitchen of her mother's house. "Just like today, it was hot outside and building up for rain," Martinez said. "I remember looking down at the kitchen counter and seeing a knife. And suddenly that knife seemed like the only way to cut out every pain inside me. So I picked it up and started to saw through the skin on my wrist."

As Martinez was telling this story at her kitchen table, there was a rumble out of the sky, as thunderclouds massed—Wakinyan, the Oglala Lakota call them, Thunder Beings. "The sixth time I was trying to cut, the floor beneath me rumbled," Martinez said. "Wakinyan were speaking to me. They were telling me I had to live. I dropped the knife."

For a moment we sat in the sultry, fly-buzzing

In 1868 men came out and brought papers.
We could not read them, and they did not tell us truly
what was in them... When I reached Washington
THE GREAT FATHER EXPLAINED TO ME
...that the interpreters had deceived me.
All I want is right and justice.

*Red Cloud, ca 1822–1909*

silence. She lit a twist of sage, and we took turns wafting the cleansing smoke around our hair. A small commotion erupted outside. Although money is always tight, and Martinez has three children of her own (who are 19, 11, and 5), there is often a posse of unrelated or half-related youngsters hanging around, participants in Martinez's somewhat haphazard youth-leadership endeavor. Today was no exception. Several boys, ranging in age from 14 on up, were running in circles around her humid, overgrown garden, shooting at each other good-naturedly with pellet guns. One of them had been shot in the rear and was wailing. Martinez laughed and got to her feet. "Oh my warrior youth," she said. "Let's find out who did what to who."

IT IS PERHAPS ONLY NATURAL that Martinez, who grew up on the rez in the 1970s and early '80s, has radical tendencies. "Those were crazy times," Martinez told me. Unseen people walked at night, heavily armed; houses in the more remote towns were frequently shot at after dark; there were scores of killings. "You can dance words around it, but what was happening back then felt a lot like a war to the people who were in it," she said. In February 1973, 200 members of the American Indian Movement (AIM), a pro-native group that included Martinez's young parents, occupied the site of the Wounded Knee massacre to protest broken treaties and corrupt tribal governance. In response the tribal government formed its own private militia—Guardians of the Oglala Nation, they called themselves (GOONs for short)—and along with dozens of National Guard troops and FBI agents, faced down the activists. By the time the siege was over, 71 days later, 130,000 rounds had been fired, and authorities had made more than 1,200 arrests.

Martinez and I were talking about this one late afternoon at the Wounded Knee Cemetery, not far from her house. "I am a direct result of that revolution," she said. We had spread out in the shade of a tree that also sheltered her father's grave. Angelo "Angel" Martinez had died in a car crash in 1974, when Martinez was a baby. It is a measure of the esteem he was held in by AIM members that his funeral included an elaborate procession from the village of Porcupine and burial in this highly significant cemetery. "Right here at Wounded Knee," Martinez said, digging her finger into the ground. "This is where the idea of me happened."

Looking at it head-on, the 1973 siege did not achieve its goals. Broken treaties between the U.S. and the Oglala Sioux remained broken, the tribal government remained as corrupt as ever, and those rebellious days had a long and violent afterlife. Between March 1, 1973, and March 1, 1976, the murder rate on the Pine Ridge Reservation was more than 17 times the national average. But the AIM activists had

made two things abidingly and indelibly clear. The U.S. government could never again dismiss Indian people as a bothersome obstacle to an otherwise perfectly executed manifest destiny, and being native, resisting colonization and assimilation was something to which people could proudly dedicate their lives.

ONE AFTERNOON a few weeks later Martinez and I drove two hours northwest to deliver a birthday cake to a niece by marriage, who had recently been raped on the rez and had fled to a women's shelter in Rapid City, South Dakota. On the way Martinez pointed out several unmarked state police cars. When I asked her how she could tell, Martinez said, "I can spot a pig a mile off. It's the way I was raised by my mother."

It's true that Victoria Thunder Hawk had presciently prepared her child for jail, because whatever else was up for grabs in Martinez's future, incarceration was inevitable. "I grew up on marijuana money," Martinez said. "It's how my mother took care of us and funded her work in the resistance. So she always used to tell us, 'Just remember, when they come for you, keep your head up and mouth shut.'" Martinez said the whole rez community seemed to come through their doors to buy marijuana when she was a kid, "teachers, cops, neighbors. I thought everyone smoked." But Thunder Hawk never got rich on the trade, sharing her profits liberally with the community. Also, she viewed marijuana as a medicine that would allow her people to heal from oppression and to tap into a creative, contemplative frame of mind. By the time Martinez was 30, she had been involved in selling drugs for most of her living memory. "It was just a matter of time," Martinez said. "You know? You get selfish, you get careless, you get caught."

By now we had delivered the birthday cake and were driving through Rapid City's downtown, with its once-we-were-cowboys-and-Indians public art. But as Martinez kept insisting, the past wasn't neatly done and dusted, as the bronze statues of cowboys would suggest. It was here and now. A day earlier, on August 2, a 22-year-old Indian man originally from the reservation, Daniel Tiger, had shot and killed a police officer in an altercation at a bus stop in the city. Tiger too had been shot and died of his wounds, another officer had died, and another was recovering in a hospital. "White people always say there's nothing racist about it," Martinez said. "But that's because they're not native. Maybe it's time we made the boundaries around the rez impenetrable. Keep the Indians in, keep the crackers out. Then we can just get on with it. No more cowboys and Indians."

**121.3**
**Liver disease deaths per 100,000, PINE RIDGE RES. (Shannon County)**
**9.7 UNITED STATES**

**37.2**
**Suicides per 100,000, PINE RIDGE RES. (Shannon County)**
**10.9 UNITED STATES**

Martinez pointed to a stark, square building to her right. "Pennington County Jail," she said. "That's where I spent my 11 and a half months in hell." She looked over at me. "They got me for conspiring to distribute. But I didn't snitch on anyone. I did my time. Head up, mouth shut, just like my mother told me."

Martinez said the worst part of her died in that jail. "The greedy, selfish Martinez died in those walls. She's buried there." She reached over, patted my arm, and laughed. "Don't you think that's a good place to bury a colonized Indian ass? In a white man's jail." Encouraged to participate in sobriety classes, Martinez was unequivocally clearheaded for the first time in decades. "Then when I was having revelations, when I was feeling the spirits, I knew I wasn't hallucinating. I started to trust my visions." Sitting in a windowless cell, Martinez said, she saw her future. "I could see dozens of tepees set up in a meadow and young warriors everywhere, flags and braids and camouflage flying. I was in the middle of them, and my children were with me." Martinez shut her eyes, and for a moment all the hurt and the fight went out of her face.

IN THE EARLY SPRING of 2011 Olowan Thunder Hawk Martinez briefly caught the edge of the vision she had had in jail. For a few weeks in that unkind South Dakota season, she borrowed

a tepee and set it up on land she had inherited from her mother, who had died while Martinez was incarcerated. Martinez was not permitted to attend her mother's funeral. "She died with an outstanding warrant for her arrest hanging over her head, for the same thing that landed my ass in jail," Martinez said.

By conventional Western mores, Martinez's vision would seem unambitious to the point of meaninglessness. Still, her mother would have approved of Martinez's setup on her land. And it's something Alex White Plume would respect too. "Everything in the U.S. is designed around money," he had said to me. "So how do we live in that mode—with the white man's houses, the white man's pickup, the white man's currency—and still keep our traditional Lakota culture?"

In the tepee Martinez heated baked beans over an open fire surrounded by her two young daughters, her son, and half a dozen coming and going Oglala Lakota youth. As in her vision, the youngsters were dressed in camouflage, many of them wore their hair in long braids, ribbons were flying. For a few sacred weeks Martinez wasn't in mold-infested, government-issued housing. She was off the grid. (She can rarely afford her electricity and water bills when she isn't.) She woke up early and walked out of her tepee and directly into the grace of the morning star, to which she gave her Lakota thanks.

And outside the tepee, against the restless Great Plains sky, bleak with heavy spring snow clouds, Martinez raised an American flag, union down. According to the Flag Code of the United States of America, the flag should never be displayed union down, except as a signal of dire distress or in instances of extreme danger to life or property. "That's almost right," Martinez said. "We're in dire distress, but we don't need anyone to come and save the Indian. When we honor our customs, and when we perform ceremonies, and when we listen to our ancestors, then we have everything we need to heal ourselves within ourselves." Martinez thought for a moment, and then she added, "Write this: When the lights go out for good, my people will still be here. We have our ancient ways. We will remain." ▯

A candlelight vigil is held to honor 15-year-old suicide victim Dusti Rose Jumping Eagle. The suicide rate for the Oglala on the reservation is more than three times as high as for the U.S. population as a whole. "No matter how young, they know about suicide on the reservation," says Eileen Janis, a suicide prevention leader.

Possessing alcohol or being under its influence is illegal on the Pine Ridge Reservation. But in Whiteclay, Nebraska (population around a dozen), on the reservation boundary, four liquor stores sell some four

million cans of potent malt liquor annually. Alcoholism afflicts eight out of ten Oglala families. The tribe has filed suit against beer distributors for knowingly making alcohol so readily available.

A young man suffering from the effects of a neurological disease and alcoholism sleeps in the living room of his home, six miles from the nearest town. Since the photograph was made, in May 2011, the house has been condemned, and he and the other occupants have moved elsewhere.

Lenny Jumping Eagle rides in a celebration of the defeat of Colonel Custer in the Battle of the Greasy Grass (the Battle of the Little Bighorn), June 25-26, 1876. Every year dozens of long-distance rides or horse races on and beyond the reservation commemorate great leaders, sacred lands, and historic events.

Out of the Indian
approach to existence
THERE CAME A
GREAT FREEDOM,
an intense and absorbing
love for nature…enriching
faith in a Supreme Power;
and principles of truth,
honesty, generosity, equity,
and brotherhood as a guide
to mundane relations.

*Luther Standing Bear, ca 1868–1939*

With the reverence afforded a sacred being, Oglala men fell a specially chosen cottonwood tree and carry it to the center of a Sun Dance circle. Erected in the earth, the tree will become the focus of a days-long spiritual ceremony. Sun Dances and other traditional ceremonies have undergone a resurgence since the 1970s.

# Spiritual Ways

A woman prays beside a sacred Sun Dance tree after the ceremony has ended. During the Sun Dance a medicine man guides certain men in making a solemn offering. They are attached to the ropes by bone pegs piercing their chests or backs and must tear themselves free. The colorful ties on the tree contain tobacco and other offerings and represent prayers for the people and for all of creation.

After intense communication with the spirits, participants emerge from a steaming *inipi*, or purification (sweat) lodge. This ceremony was held by Rick Two Dogs, a medicine man descended from American Horse.

Perhaps you have noticed
that even in the very lightest
breeze you can hear the voice
of the cottonwood tree;
THIS WE
UNDERSTAND IS
ITS PRAYER TO THE
GREAT SPIRIT,
for not only men, but all things
and all beings pray to Him
continually in differing ways.

*Black Elk, ca 1863–1950*

Nine-year-old Wakinyan Two Bulls places prayer flags in a tree near Mato Tipila ("bear lodge"), or Devils Tower, in Wyoming. The story of the Oglala—their spirituality and their fight to remedy old wrongs—goes well beyond the Pine Ridge Reservation.

# Daring Divers
# GANNETS

*Champion divers but clumsy landers, doting parents but hostile neighbors—northern gannets abound in contradictions. Long tied to maritime cultures, they're flourishing today in crowded colonies around the North Atlantic.*

*At Hermaness National Nature Reserve in Scotland's Shetland Islands, adult gannets soar above the coastal churn. Snugly insulated by thick feathers and fat beneath their skin, these far-foraging seabirds are built for life in cold, turbulent waters.*

By JEREMY BERLIN
Photographs by ANDREW PARKINSON

# Fifty feet above the storm-tossed North Sea,

a thunderhead of birds has been massing. When the cloudburst comes, it's quick as lightning. They plunge, a score of white tridents, spearing the waves with a thump and a splash. Moments later they bob to the surface, fish in throat. They shake their heads, rise from the water on six-foot wings, and soar to cliffside homes with a swan's grace. There they land badly and bicker loudly.

These are northern gannets, far-ranging seafarers tethered seasonally to crowded colonies. Science tells us *Morus bassanus* is a cousin of the booby, but the eye sees a seagull crossed with an albatross. As elegant in flight as they are hapless on land, they are by turns bumptious and balletic, territorial and tender, dramatic and comical. They are, in the words of the wry Scottish naturalist Kenny Taylor, "birds of contrast."

So let us count the ways, and let us begin with a cheering score. By 1913, centuries of hunting had thinned their ranks, once unknowably large, to perhaps 100,000 birds, their colonies to fewer than 20. A hundred years of protection later, gannets are one of conservation's great success stories. Today 40-odd sites around the North Atlantic harbor some 400,000 nesting pairs, plus tens of thousands of juveniles and nonbreeders.

One large colony resides at Hermaness, a national nature reserve at the top of Shetland. This is the northernmost point in Britain—the edge of the world. With 500-foot gneiss cliffs plunging into tidal cauldrons dotted with arched skerries, the site—named for a giant who loved a mermaid—is steeped in myth. When you reach it, the miles of sodden moorland you've tramped fall away into a chasm of sea and sky, where wind and wave skirl and roar.

Gannets began nesting here in 1917, and in summer months their molting feathers fill the air like fairy dust. The colony itself is a riot of squawking, flapping, and jabbing. The choicest nest sites are in the center, as valuable and rare as rent-controlled apartments in Manhattan. Once acquired, they're defended with life and saw-toothed bill. Single birds lurk on the fringes, seeking a partner and a nest of their own.

To get a site, two males will fight, locking bills and stabbing faces, for up to an hour. When the clash ends, one gannet leaves; the other has a home. "The bird is faithful to the site once it occupies it," says Stuart Murray, a gruff Scotsman who's been surveying Britain's seabirds for four decades. "They attract a mate, she lays an egg, and then they think, Bingo! I've done it!"

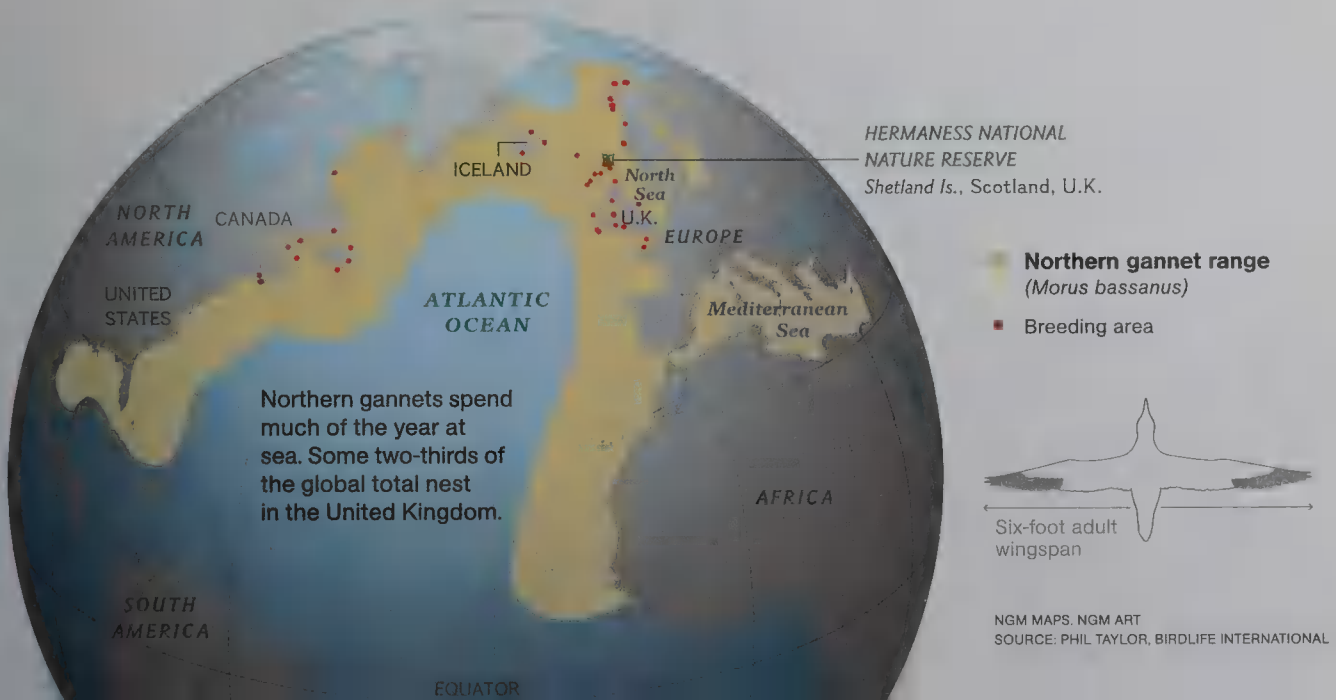
Each season equals one egg, plain and white like a goose's. Parents take turns incubating it and, after six weeks, feeding what emerges—a shriveled thing, naked and ebony. Over three months it will become a downy, white powder puff, then a slate-plumed juvenile. Two meals a day swell it swiftly; calisthenic wing flapping tones it crucially. When a chick is ready to leave the nest, it splashes into the sea. "At first it just bobs on the waves, bewildered," says Murray. "But hunger pangs drive it to swim and dive. Then it will learn what to do by watching other gannets." Growing up will be hard and perilous. Less than half will see a third birthday.

If gannets have a calling card, it is the spectacular feeding behavior called plunge diving. Watching these birds plummet headlong to wrest life from the frigid depths, one thinks of Tennyson's eagle, of crawling seas and falling thunderbolts. One also sees why fishermen have long relied on them as location scouts. Indeed, the human-gannet relationship stretches back centuries. Beowulf's liege lord, Hrothgar, called the ocean a "gannet's bath." John Daniels, who photographed the Wright brothers' first flight, said Orville and Wilbur "would watch the gannets and imitate the movements of their wings with their arms and hands." And melted gannet fat was once used for everything from gout balm to wagon-wheel grease.

Today, with few natural enemies and abundant food sources, the northern gannet seems primed to thrive. Still, as with most seabirds, its life is a daily proving ground of water and weather. Even in these days of protection and plenty, says Murray, "it's a high-stress business, being a gannet." □

DAVID TIPLING, BIOSPHOTO

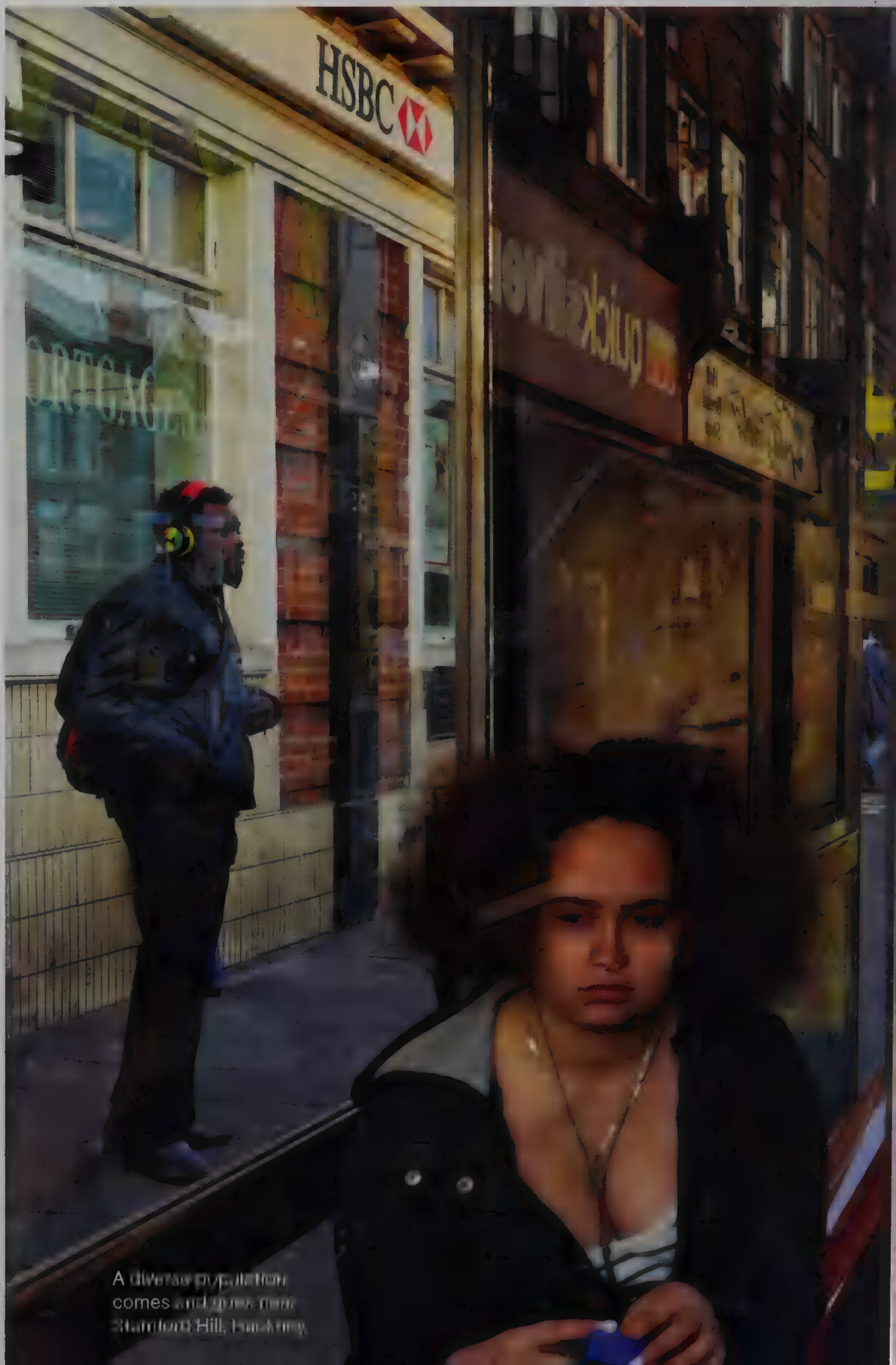
*Binocular vision lets gannets spy deep fish shoals. When the birds break the surface, at up to 70 miles an hour, air sacs buffer their heads and chests. Nostrils that seal shut let them dive to depths of 50 feet.*




NGM MAPS. NGM ART
SOURCE: PHIL TAYLOR, BIRDLIFE INTERNATIONAL

*Two landing adults raise the ire of their Shetland neighbors, a common sight in a hectic colony. But beneath the territorial clamoring is a ritualized order. Nests are arranged in a canny geometry of two per ten square feet—just out of jabbing range.*

# East side




A diverse population comes and goes near Stamford Hill, Hackney

# Story

**The "other London"—gritty, graffitied, but with a rising cool index—gets ready for its close-up as the venue of the Summer Olympics.**

Soldiers in the service of Jesus Christ, men and boys of the Nigerian Cherubim and Seraphim Church of Zion Imole in Hackney march up to the collection box to put in their offerings.

Home is where the harbor is for houseboat residents along the latticework of East London's canals. This picnic unfolds by Hertford Union Canal, near the site of the 2012 Olympics.

LONDON TOWN

Pearly Queens Jackie Murphy, daughter Teresa Watts, niece Sharon Crow, and cousin Phyllis Broadbent sing in a Leyton pub. The Pearlies are a traditional Cockney charitable organization.

**After the last customers had wiped the stray crumbs of meat pie from their faces. After the last jellied eel had slid down throats. After the last cup of tea had been swallowed,**

Fred Cooke, owner of F. Cooke's pie and mash shop at 41 Kingsland High Street, London E8 2JS, flipped the hand-printed cardboard sign on the front door of the establishment his grandfather had founded when George V assumed the throne from OPEN to CLOSED.

"You bet there were tears," Cooke said of that day, February 11, 1997. Cooke, a thick-bodied man with thinning hair on top that gathered momentum to crest in a lush white wave at the back, stared wistfully at a case in the Hackney Museum. The display featured the net he had used to scoop eels out of the tank, pots for boiling potatoes for the mash, steel pie pans, and paper bags with F. Cooke printed on them for carryout. The kitchenware of a three-generation-old family enterprise had become a museum artifact.

"We were the Buckingham Palace of pie and mash shops," he said. The diamond stud in his right ear and a gold bracelet, thick as a handcuff, testified to the rewards. The pie and mash shop on Kingsland High Street, one of six owned by the Cooke family, had been the flagship of the fleet, but the ship had been scuttled in response to the changing social landscape of East London.

Pie and mashed potato drenched in neon green parsley sauce, a bowl of eels in a gelatinous matrix, is a vanishing emblem of East End's white working class, which has been replaced by a tide of emigrants from the Indian subcontinent—the legacy of the London docks that were once the gateway out to the rest of the British Empire and the gateway in for immigrants. The Huguenots arrived in the 17th century seeking freedom from religious persecution. In the 18th and 19th centuries the Irish fled famine. Eastern European Jews escaping the pogroms of Russia were next. Now the predominant ethnic group is Bengali; most are Muslim. They began immigrating in large numbers in the 1960s for economic reasons and now make up a third of the population—but there are also Africans, West Indians, Pakistanis, Indians, Turks, Chinese, and Eastern Europeans.

On Cambridge Heath Road in Bethnal Green, the Al-Rahman Supermarket, with its HALAL MEAT sign, rubs shoulders with the Polski Sklep Mini-Kłos Polish grocery, across from the Somali Mayfield House Day Centre, down the block from the luxury Town Hall Hotel, with a BMW or two parked in front and its £2,500 ($4,000)-a-night De Montfort suite (triple-height ceiling, stained glass windows, room for 16 to dine). Around the corner is York Hall, venue for Saturday night boxing ("Bad Boy Promotions presents: a night of white collar boxing with José 'KO' Corrodus and Lee 'the Bomber' Banks"), and steps away, the Gallery Cafe, where mothers with children in prams drink lattes and young professionals hunch over laptops. There is the crackle of energy, the jazz of diversity; it's a bazaar to pick and choose from according to your taste, mood, and wallet.

The number of East End pie and mash shops—Cooke remembered 14 or 15—could almost be counted on one hand now. "East London became cosmopolitan," Cooke explained. It was unclear if he meant this as a compliment. "They want their peas and rice, mon, and their kabobs." It was said lightly, with an undertow of edge but mostly with resignation.

THINGS GO MISSING. We drop a glove. Lose a watch. Misplace our glasses. Sometimes they reappear, are appropriated by others, or stay lost. East London is like that. A landscape of disappearances; streets scribbled with traces of the past, a tangle of bits and bobs that alternately

vanish, then show up again in different form. A turn-of-the-century Jewish soup kitchen for the poor on Brune Street is reborn as luxury apartments. An 18th-century French Protestant church becomes the Spitalfields Great Synagogue in 1897, then 80 years later turns into the Brick Lane mosque, a testament to Lavoisier's dictum that matter is neither created nor destroyed but simply changed from one form to another.

F. Cooke's pie and mash shop in Dalston was sold to a Chinese businessman, who renamed it the Shanghai. Instead of eels, the menu lists baked lobster with ginger and spring onions. Instead of meat pies, pork dumplings. "I carried on as good as I could," Cooke said, "but there was no use in flogging a dead horse. I decided to get out and enjoy the rest of my life. Nonetheless, it broke my heart."

TRACE A LINE starting at Tower Bridge along the north bank of the Thames; go east to the River Lea; turn north, looping in the borough of Tower Hamlets and part of Hackney; go south, to the old Roman walls of the City, and you have the classic East End of Charles Dickens, Jack the Ripper, and the celebrity gangsters of the 1950s and '60s, the Kray brothers—Reggie and Ronnie, of whom one East Ender said: "The Krays were on the streets killing, but they would take care of your mother."

This, historically, is wrong-side-of-the-tracks London. Its proximity to the Thames, and the eastern flow of the river, made the downstream location of shipping and manufacturing a natural consequence. Located beyond the walls of the City, noxious industry—tanneries, abattoirs, lead-smelting furnaces—could operate with minimal oversight. Winds blew from the west, lobbing the stink right across the East End, away from the perfumed air of the genteel West. The industrial revolution and expansion of the British Empire under Queen Victoria exacerbated the sordidness. The huge demand for dockworkers shoehorned even more working-class residents into an area swollen by immigration. Overcrowded housing proliferated. Poor sanitation spread disease. "Not a wery nice neighborhood," observed Sam Weller in Dickens's *Pickwick Papers.*

UNLIKE THE HOMOGENIZED grandeur of West London, with its Parliament and palaces, East London's landscape was—and remains—unruly and unkempt. There are oases of loveliness: The quiet calm of houseboat-lined Regent's Canal; the orderly and expensive Georgian houses on Fournier Street, where the edgy lions of British contemporary art like Tracey Emin and Gilbert & George live; the green of Victoria Park, opened in 1845 by grace of a petition signed by 30,000 East Enders, as well as West Enders who wanted a barrier to the diseased air of the East. But there is squalor in the brutal concrete of low-income housing estates, their corridors shading the furtive transactions of drug dealers, the stale smell of urine in stairwells; in the street gangs; in the brown fields with the toxic detritus of moribund factories; in the marshes scarred by rows of electric line pylons and rusting gasworks.

Today East London broadens out—depending on whom you ask—to include the boroughs of Newham, Barking and Dagenham, Redbridge, Waltham Forest, and Havering. Whatever the boundaries—despite more than a century of regeneration, despite neighborhoods colonized by white-collar professionals and more than 170 art galleries and museums, despite the prosperity of Canary Wharf's financial district and its Masters of the Universe skyscraper headquarters for HSBC, Barclays, and Citibank—East London is still the quarter of the city most haunted by deprivation.

From 1889 to 1903 the Victorian social scientist Charles Booth published a map series of London poverty that scribed the East-West divide. On Booth's map the West End of Kensington and Belgravia gleam with gold rectangles denoting "Upper-middle and upper classes. Wealthy." The East End is riddled with black patches signaling "lowest class" and blue squares signifying

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*Editor at Large Cathy Newman admires Brits for their wit and civility. East London reminds Alex Webb of Brooklyn, his home borough in New York.*

"chronic want." An index of deprivation in London today would read pretty much the same.

In 2005 the International Olympic Committee awarded the 2012 Olympics to London. The city announced it would use the games as an opportunity to transform East London and tackle "poverty, unemployment, lack of skills and poor health." The Olympics would be, Jack Straw, then foreign secretary, promised, "a force for regeneration."

IN EAST LONDON disparities between the haves and have-nots are in high relief. In Bethnal Green you can order a sausage roll (£1.40) and a cup of tea (70 pence) and eat at the Formica tables with plastic-covered chairs at Hulya's, or nip across the street and ease yourself into the handmade furniture at the Michelin-starred Viajante for squid tartare with squid ink granita, followed by, say, duck heart and tongue with mushroom floss and spiced broth (six courses with wine pairing, £115).

"London," says Danny Dorling, a professor of human geography at the University of Sheffield, "is the capital of inequality." As they say on the London Underground: Mind the Gap.

Turn right on Hanbury Street off Brick Lane facing toward Bethnal Green Road and you approach some of the meanest low-income housing estates in London. Turn left and you approach the terminally cool district of Shoreditch, home of 300 or more digital-based, high-tech businesses.

"Entrepreneurs need four things," explained Elizabeth Varley, a founder of TechHub, just off Old Street, where for £3,300 a year, developers of Web apps and cloud-based products who are hoping to come up with the Next Big Thing can buy desk space. "They need power, a superfast connection, unlimited coffee, and great creative people around them."

East London has become a high-tech nexus, she explained, because of its affordability, its proximity to the city, and the "common vibe." "The area is full of artists, restaurateurs, and retailers, people who want to do things their way."

People like 24-year-old David Tenemaza Kramaley, a computer game developer, who sold his first digital product at 13 for £1,000, was looking to raise £300,000 for his latest venture, and had just moved to a one-room windowless basement

## The Rising East

"The East End of London is a world in itself," wrote Charles Dickens. The constellation of skyscrapers in Canary Wharf's financial district (opposite) is a world within that world, built from docklands abandoned in the 1960s, when shipping moved downriver to deeper water.

flat five minutes from work, for which he was happily paying £1,000 a month.

"I like living here because of the convenience and ability to network," he said. Kramaley, whose round face is framed by a Beatle-like mop of black hair, relishes the roller-coaster ride of a start-up. "I know I could get a well-paid job doing coding or marketing, but I like being in control of my own destiny."

His goal?

"To make two million pounds."

"EVERYONE KEEPS LOOKING for the newest immigrants," said Sotez Chowdhury, 22, a Bengali community organizer for Shoreditch Citizens. "They keep wondering—which ethnic group is next? I keep saying, These *are* the new immigrants, and you can't say they don't belong." He meant the young professionals who had moved in, lured by the vibrancy and hipness of the place.

One night Sotez; his mother, Rowshanara, who is a family therapist; and I walked down Brick Lane, the heart of Banglatown, as it's called. The lower end of the street with its curry restaurants (there are more than 50) glowed with the flamingo pinks, acid greens, and garish yellows of neon signs; the air practically vibrated with the smells of curry, cloves, and burning charcoal and the blaring Bollywood music.

At Woodseer Street, *(Continued on page 94)*

NGM MAPS
SOURCE: OPENSTREETMAP

NSKY'S

**There is the crackle of energy,**
**the jazz of diversity; it's a bazaar to pick and choose from according to your taste, mood, and wallet.**

**THE MIXING BOWL OF EAST LONDON** contains young, old, rich, poor, gay, straight, and everything in between. The A1 barbershop on Commercial Road (above) caters mostly to customers from Pakistan and Bangladesh. At day's end young professionals in the Canary Wharf financial district relax over drinks (top left). The Joiners Arms Gay Night takes place at Cordy House, an event space in Shoreditch (left). "There's less tension than one would expect," says Geoff Mulgan, former director of the Young Foundation, which creates programs to address social issues in East London. "It's healthy, the opposite of ghettoization."

USA VRX

Worshippers offer prayers at a funeral service in the Turkish Süleymaniye Mosque in Shoreditch. "Our neighbors accept us and see us as one of them," says director Huseyin Hakan Yildirim.

**Unlike the homogenized grandeur of West London, with its Parliament and palaces, East London's landscape was—and remains—unruly and unkempt.**

**LIVING ON THE ROUGH EDGES,** but getting by, John Cook (above), aka John the Poacher, hunts rabbits in nearby marshes and sells them from his "office" in the Anchor and Hope pub. "There's nowhere else in London I'd rather be than Hackney," he says. Sibel Beliczynska (left), a Cypriot with two children, is unemployed, on benefits, and looking for work. An older generation favors the Mecca Bingo clubs in Hackney (top left), where a pint sets you back two quid while you wait for the numbers to line up. By any measure—unemployment, income, life expectancy—most East London boroughs sit at the bottom of the barrel.

a Maginot Line of sorts, demographics change: Curry Restaurant Brick Lane turns into Boutique Brick Lane, with vintage clothing stores, music clubs, and bars filled with young men with sandpaper beards and young women in leggings and abbreviated tops. The Brickhouse bar and supper club that week promised the burlesque chanteuse Lady Beau Peep, along with Audacity Chutzpah, Bouncy Hunter, and Vicious Delicious.

An old Bengali man struggled to make his way against a tide of young people. "This used to be his neighborhood," Sotez said of trendy Brick Lane, beyond Woodseer Street. The street was filled with the careless exuberance of a different generation, with money to spend. Did they have any sense of the deprivation that lay just around the corner? I asked Rowshanara. "They don't have a clue," she said.

"I'd come here with my friends from uni," said Sotez. "It's vibrant. It's cool. We'd have a look around. From here you can see the lights of Canary Wharf, but they turned out to be an illusion." He paused and his face seemed to harden. "My mates all wanted to be investment bankers. None of them are."

IN ONE OF THOSE gleaming glass towers in Canary Wharf, Jerome Frost, head of design for the Olympic Delivery Authority, leaned forward on an impeccably white-topped table of the sort that telegraphs modern design and explained the driving force behind the London Olympics. "The games present a unique opportunity for London," he explained. "We would reinvent the event. Make it more sustainable. The bid we made to the Olympic Committee was positioned on what we would leave behind." The games were dubbed the "legacy Olympics." In developing the site, the ODA cleaned up a square mile of contaminated land, buried power lines underground, and created 200 acres of new parkland. No environmentally correct detail was too small: 2,000 newts were carefully relocated away from the construction to a nearby nature reserve.

After the Olympics the buildings would find new life as community sport centers, and the athletes' village would become private housing—half, it was said, earmarked for low-income buyers. The regeneration bounty would spill over to the surrounding area. Westfield Stratford City, one of Europe's largest shopping centers, had recently opened in Stratford, gateway to the Olympics, with 1.9 million square feet of brand-name shops.

Impressive, though the trumpeted word "legacy" provoked skepticism in some precincts. "'Legacy' is one of those words like 'cool' and 'brand,'" said Stephen Bayley, a London design critic. "You can't create a legacy. Let us not imagine that great buildings can undo a ghetto."

"Will they get it right this time?" I pressed Jerome Frost. On the plus side, he said, a chunk of East End had been cleaned up in record time and under budget, an improbable accomplishment if left to the private sector. But would those who live there really benefit? Or would it end up as another Canary Wharf, a walled-off Vatican, one urban studies scholar called it, that merely underlined the economic divide?

"If this doesn't work," Frost said with a sigh, "nothing will."

PERHAPS THE MENU needs updating?

The question was put to Fred Cooke's cousin Bob, who still runs his pie and mash shop at Broadway Market, Hackney. Bob Cooke set a bowl with a piece of eel floating in a sea of green sauce in front of me and sat down. It was tricky spooning the slippery segment out and trying to nibble around the tiny white cylinder of vertebrae in the middle.

"One of my pals said: 'Why don't you sell pizzas? Kids love pizzas.'

"I said: 'You look after your laundry. I'll look after my pie shop.'"

Cooke stood up and wiped his hands on his blue-striped apron.

"Yes, we have customers, but they're older and getting fewer. Yuppies are not our customers," he said, as a tall young man with a ponytail peered in the doorway, then walked away. "I sell 3,000 pies a week," he said. "We've been here more than a hundred years. We'll be here another hundred."

**It remains a continuum of arrivals and departures, appearances and disappearances, a human march, sometimes, of simply getting on with it.**

Noon was approaching. The street outside was packed with young people trolling the Broadway Market—which once sold utility-grade cabbages, onions, and potatoes—for organic gluten-free banana-walnut cake, pedigreed Devon beef, and truffled olive oil. There was music in the air, and the smell of fresh-baked artisanal bread. There were only five customers in the shop eating pie and mash.

IN EAST LONDON you may hear more than 200 different languages—Bengali, Gujarati, Urdu, Tamil, Swahili, Latvian, among others. Immigration makes itself heard as well as seen, but there are sounds no longer heard—like Yiddish, Brick Lane's lingua franca at the turn of the 20th century. For the same reasons white working-class Cockneys moved east to places in Essex, East London Jews moved north to suburbs like Golders Green and High Barnet. It was about aspiration: about moving up and out. Until the 1950s Brick Lane was a Jewish high street. Now practically the only trace of its former life is two bagel bakeries.

"That's my Jewish East End," said Mildred Levison, showing me the apartment off Brick Lane where she grew up during the Second World War. ("I'm sure the vermin are still there. In London you are never very far away from a rat.") We walked to Spitalfields Market, a bomb shelter during the blitz, now gentrified to within an inch of its life with boutiques and bistros. Levison, 72, retired from a career in public housing, lives in North London now. She recalled the six pence it cost for the public baths and playing in bombed-out rubble ("Brick Lane feels different but strangely the same, because my grandparents were immigrants"), as well as the warmth of community and family. "None of it is here anymore." She paused, then touched her heart. "But it's here."

It's still here, just in a different guise. East London remains a continuum of arrivals and departures, appearances and disappearances, a human march, sometimes, of simply getting on with it. Generations had landed with little or nothing and built a business, a family, a life. If poverty had retained its stubborn grip, one would do well to remember, says Alveena Malik, director of UpRising, a program to train young leaders in East London, that "being economically deprived doesn't mean you are spiritually deprived."

"I CAME FROM BANGLADESH in 1973 to continue my studies," Shahagir Bakth Faruk told me over dinner one night. "My uncle sponsored me, but there was no money, so I found a job as a shop assistant in an electronics shop in Brick Lane for £28 a week. I remember sitting in a park reading a letter from my brother. It had taken 17 days to arrive from home. My tears soaked the paper."

In time he made a new life. He started a successful business. He ran twice for Parliament as the Conservative candidate from Bethnal Green and Bow. ("And lost twice. Bethnal Green has always been Labour," he said ruefully.)

Faruk, now 64, became British. And another thing…

"In Bangladesh, if a girl wants to marry outside the Muslim religion, there is a one in a million chance the parents will give their consent. It isn't done," he said.

"But when my son came to me to say he wanted to marry a girl whose mother is Christian and whose father is Hindu, I didn't give it a second thought.

"Now, my younger son wears an earring; when a friend pointed it out, I said: 'So what?'"

Just then, his cell phone rang. His married son was checking on him.

"This city taught me an important lesson," Faruk said, putting down the phone.

"The lesson it taught me was tolerance." □

**On Saturdays, East London's newest arrivals—the young and affluent—linger in trendy cafés and trawl the stalls of Broadway Market. Formerly a locus of garden-variety fruit and veg stands, the market now offers eco-friendly bamboo socks, loin of venison, and hand-sliced smoked salmon.**

Guided by the laptop weather map reflected in his window, Tim Samaras rushes to catch up to a dying thunderstorm. He hopes to be the first to photograph the split-second event that triggers a lightning strike.

Tim Samaras has a storm in his headlights and the world's fastest high-resolution camera in the trailer behind. Can it catch lightning in the act?

# Chasing Lightning

As he waits for a wave of thunderstorms to form along Colorado's Front Range, Samaras readies the 1,600-pound camera he calls the Kahuna. A rainbow (left) signals the end of another chase.

**By George Johnson**
**Photographs by Carsten Peter**

# *It's a good thing there's a rumble strip running along the shoulder, because Tim Samaras can't keep his eyes on the road.*

It's summer, and he's driving a big, black Denali pickup pockmarked by hail and pulling a 16-foot trailer outfitted with high-speed cameras and other electronic gear. A laptop computer is mounted inside the cab to the right of the driver's seat, and with one hand on the steering wheel and the other on a trackball, Samaras is mousing his way around a weather radar map of the Oklahoma Panhandle. A blob of colors—red in the middle surrounded like an oil slick by orange, yellow, green, and blue—shows a thunderstorm forming northeast of Boise City.

"It's starting to spit out some pretty good lightning," he says, looking at the little yellow crosses popping up on the radar. He glances again at the laptop, where another window is tracking our position with GPS. Then comes the buzzing of his tires against the rumble strip, and he calmly steers the rolling laboratory back onto the road.

With bugs splashing onto the windshield and a spiderweb of cracks—more old hail damage—gradually growing wider, we pass through Boise City, following the storm east toward Guymon. Ahead of us clouds are boiling up like cauliflower, the classic sign of the warm, moist updrafts that separate negatively charged water droplets and ice particles from positive ones (no one knows exactly how), creating multimillion-volt potentials—like the one that just exploded in the sky ahead of us.

"Did you just see that strike?" Samaras exclaims. Then comes another, and another. He's got a pair of reading glasses dangling from his mouth, which he puts on to look at the radar, then swipes off to glance at the road. "See how that storm is anchored right there? That's what we want."

The flashes are coming every few seconds now, and the truck is hitting the rumble strip again and again. But just as he's looking for a place to pull over, the blob on the radar starts shrinking. Samaras picks up speed, but by the time we reach Guymon, 60 miles down the road, the sun has appeared, and a rainbow is arcing overhead.

"Whenever you see the rainbow, it's game over," he says. "It's a goner. I can't believe it." But at 6 p.m. his day is just beginning. The radar shows another blob forming over southern Kansas, 80 miles away.

**LATE SUMMER IS THUNDERSTORM** season in this part of the country, and since 2006 Samaras has been trying to do the impossible: capture an image of a lightning strike the moment it is born. The process typically begins when a descending zigzag of negatively charged electricity—a stepped leader—feels its way from cloud to ground. When it gets near enough, positive fingers of charge reach up from the earth. The instant the two come together, a dazzling surge of current—some 30,000 amps traveling at a third of the speed of light—leaps toward the sky. The burst of light from this "return stroke" is what you see with the naked eye, which often interprets the motion as downward. From beginning to end, the entire process takes as little as 200 milliseconds.

In Samaras's trailer there are two Phantoms, high-speed cameras capable of shooting 10,000 frames per second. They have allowed him to capture stunning slow-motion videos detailing

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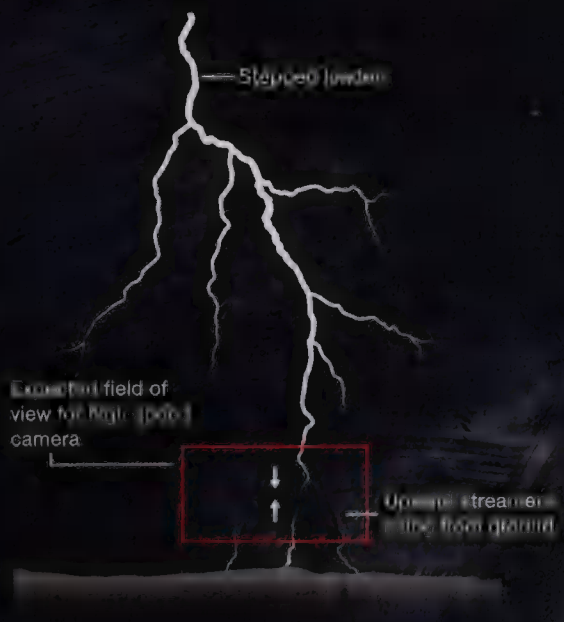
*George Johnson's most recent book is* The Ten Most Beautiful Experiments. *Carsten Peter's story on Mount Erebus in Antarctica appeared last month.*

## The Anatomy of a Strike

**1. In this high-speed camera sequence a lightning strike begins when a negatively charged "stepped leader" emerges from a thundercloud. 2. The stepped leader zigzags toward earth, branching along the way. 3. When the leader comes close enough to the ground, a positively charged streamer leaps up to meet it. Capturing an image of the moment the two connect requires an ultra-high-speed camera (graphic). 4. The "return stroke"—30,000 amps of current—surges upward, producing the burst of light visible to the naked eye. 5. The return stroke begins to decay. 6. As the light fades, more strikes can follow the same path, so quickly they are seen only as a flicker.**




GRAPHIC: SIWEN LI
TIM SAMARAS

the paths of downward stepped leaders and occasionally the upward streamers. But as soon as the two connect—initiating an event called the attachment process—the flash from the return stroke blinds the camera, obliterating the details. Scientists would love to peek behind the curtain and watch the event as it unfolds, with the return stroke lifting off like a rocket from the ground.

Lying within the imagery might be clues to some of lightning's biggest mysteries. Why will a lightning bolt sometimes strike a low tree when right beside it is a tall metal tower? And why, for that matter, does lightning strike at all? For all their intensity, the voltages produced in thunderclouds are not nearly strong enough to overcome the insulating properties of air. Some extra factor is required, and a picture of the attachment process might suggest an answer. Opening this frontier calls for a custom-outfitted camera capable of shooting more than a million high-resolution frames per second. There's just one camera like that, and it too is in Samaras's trailer.

Weighing 1,600 pounds and standing six feet high, the camera is a relic of the Cold War, originally used to film aboveground nuclear tests. Samaras first laid eyes on it in 1980, when he was working as a technician at the University of Denver Research Institute. The massive instrument was a marvel of analog technology. Light entering its main lens would strike a three-sided mirror, which sat at the center of a turbine driven by compressed air or, for really high speeds, helium. Rotating as fast as 6,000 revolutions per second, the mirror swept the light across the lenses of 82 35-millimeter film cameras, mounted shoulder to shoulder around the rim. The result was a sequence of images less than one-millionth of a second apart.

Samaras's job involved studying conventional explosions, and he became the behemoth's keeper, learning its idiosyncrasies, catering to its whims. Twenty-five years later, when he heard that the camera was being auctioned as government surplus, he placed a bid and bought it for $600—a hair above the price for aluminum scrap. Its proper name is a Beckman & Whitley 192. Samaras calls it the Kahuna.

With the help of funding from National Geographic, he retrofitted the beast, replacing the film technology with extremely sensitive digital sensors designed for deep-space exploration and adding specially tailored software and circuitry. But no matter how you modify it, an instrument weighing close to a ton has obvious drawbacks. In addition to its lack of maneuverability, the astoundingly fast Kahuna is in another sense very slow. Each time you want to take an ultra-high-speed shot, you have to wait about ten seconds for the turbine to spin up to speed. Then you have about a minute before you have to spin it down so it doesn't overheat. If you've been lucky enough to capture an image, it will take a full 20 minutes to download the 1.8 gigabytes of data to see what you've got. Only then can you recock the trigger and try again.

In other words, Samaras will need a stationary storm that is producing lightning again and again, right where the camera is pointing. Some people rate his chances of success at close to zero. There are research facilities where he could reduce at least some of the variables by deploying the Kahuna on lightning triggered by firing rockets into storm clouds. But Samaras is dismissive of manufactured lightning—only the wild type will do.

He is used to having people tell him that what he's trying can't be done. Before he became obsessed with lightning, he spent several years chasing after tornadoes. He had designed electronic probes, mounted with video cameras and other instruments, to lay down in the likely path of a tornado so he could record what it looks and feels like from the inside. People were dubious about that too, but he managed to gather some of the most accurate readings ever of wind speed, barometric pressure, temperature, humidity—the ingredients that when mixed just so erupt into a devastating funnel of wind.

With hopes of catching up to the storm, we pass through Liberal, Kansas, and then head straight north toward Sublette. A dark mass of clouds is building over the plains. As the sun sets, the tops of the clouds cool. That means more uplift, more separation between negatively and positively charged particles, and more lightning. By the time we pull to the side of the road, the storm has become so violent that in the distance it has spawned a small tornado. The twister quickly dissipates, leaving a spectacular lightning show. Two long bolts crisscross the sky like an electrified *X*, followed by a barrage of ground

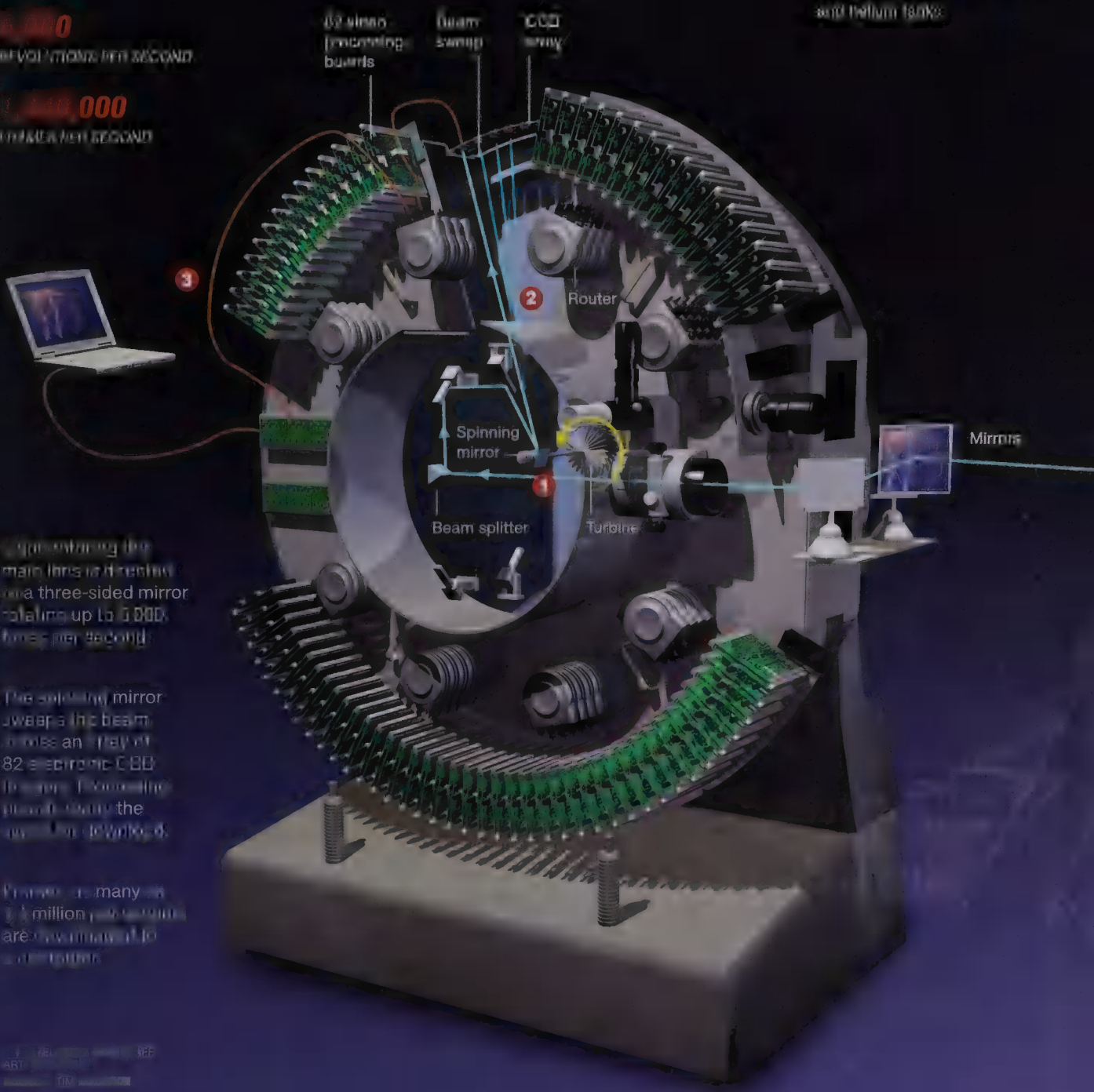
**Society Grant** Tim Samaras's lightning and tornado research is funded in part by your Society membership.

# King of Cameras

Originally designed to record ultra-high-speed images of nuclear explosions on 35-mm film, the 1,800-pound Beckman & Whitley 192 framing camera has been retrofitted with modern electronics. At its heart is a three-sided mirror mounted on a rapidly spinning turbine driven by compressed air or helium.

**6,000**
REVOLUTIONS PER SECOND

**1,000,000**
FRAMES PER SECOND




1. Light entering the main lens is directed onto a three-sided mirror rotating up to 6,000 times per second.

2. The spinning mirror sweeps the beam across an array of 82 electronic CCD imagers. Recording circuitry stores the [illegible] digitized.

3. Processing as many as [illegible] million pixels per second, are [illegible] to [illegible]

Taking aim at a storm with a laser, Samaras waits for the right moment to fire up the Kahuna. The enormous camera is too unwieldy to quickly reposition, so he targets stationary storms that produce frequent strikes.

strikes. Samaras starts up a gasoline generator, and the equipment inside the trailer comes alive. A wall of video screens displays weather information, and an electronic voice—the Lightning Lady, I call her—matter-of-factly announces the distance of the strikes: "17 miles, 15 miles, 11 miles." Then she gives a warning: "Very high electric field."

"The electric-field meter is going absolutely nuts," Samaras observes. A sensor mounted on the shell of the trailer measures the charge of the atmosphere at ten kilovolts per meter and rising, meaning that it's dangerous to be outside. The two Phantoms aboard the trailer go to work, capturing images of the milliseconds before and during the lightning flashes. Thunder is cracking above us. But throughout the cacophony, the Kahuna sits quietly off-line. The conditions just aren't right for getting the shot.

We pack up and move on, and soon another rainbow—a double one—appears. Samaras stops the truck in the middle of the main intersection of Clayton, New Mexico, oblivious to the honks and cursing drivers, while the *National Geographic* photographer takes some pictures, of the ordinary kind.

**ON LABOR DAY WEEKEND**, toward the end of the season, I caught up with Samaras at an exit off I-25 in Belen, New Mexico. By then he and his crew had driven more than 10,000 miles across six states, collecting hundreds of megabytes of data from the Phantoms—but only near misses with the Kahuna.

With only two days left in the summer's expedition, we followed a battery of storms north of the Magdalena Mountains. In midafternoon we found ourselves parked, purely by coincidence, directly across Highway 60 from the turnoff to the Langmuir Laboratory for Atmospheric Research—a premier spot for studying rocket-triggered lightning. A storm hung suspended over the mountains as if posed for a portrait, sparking lightning obediently above a distant ridge. Standing in the foreground on the other side of the highway, a cow gave us a curious eye. Using the animal as a reference point, Samaras started up the turbine and took aim. The sky flashed, the Kahuna fired, and the long download of data began.

Then, with the camera off-line, there was a better strike—this one directly over the cow. Unsure of the first shot, Samaras made a split-second decision to terminate the download and try again. The chance never came. He'll never know whether that first attempt captured an image of the attachment process or just a blurry silhouette of a cow.

**BY THE TIME I SAW SAMARAS** again, two years later, he had reluctantly decided to try what he felt in his heart was cheating: aiming his camera at rocket-triggered lightning. With a new pickup truck and an improved Kahuna—he had stayed home the previous summer jiggering the electronics—he and his crew had spent another two weeks following storms across the Southwest. Now he was making the long, slow climb to Langmuir's mountaintop laboratory.

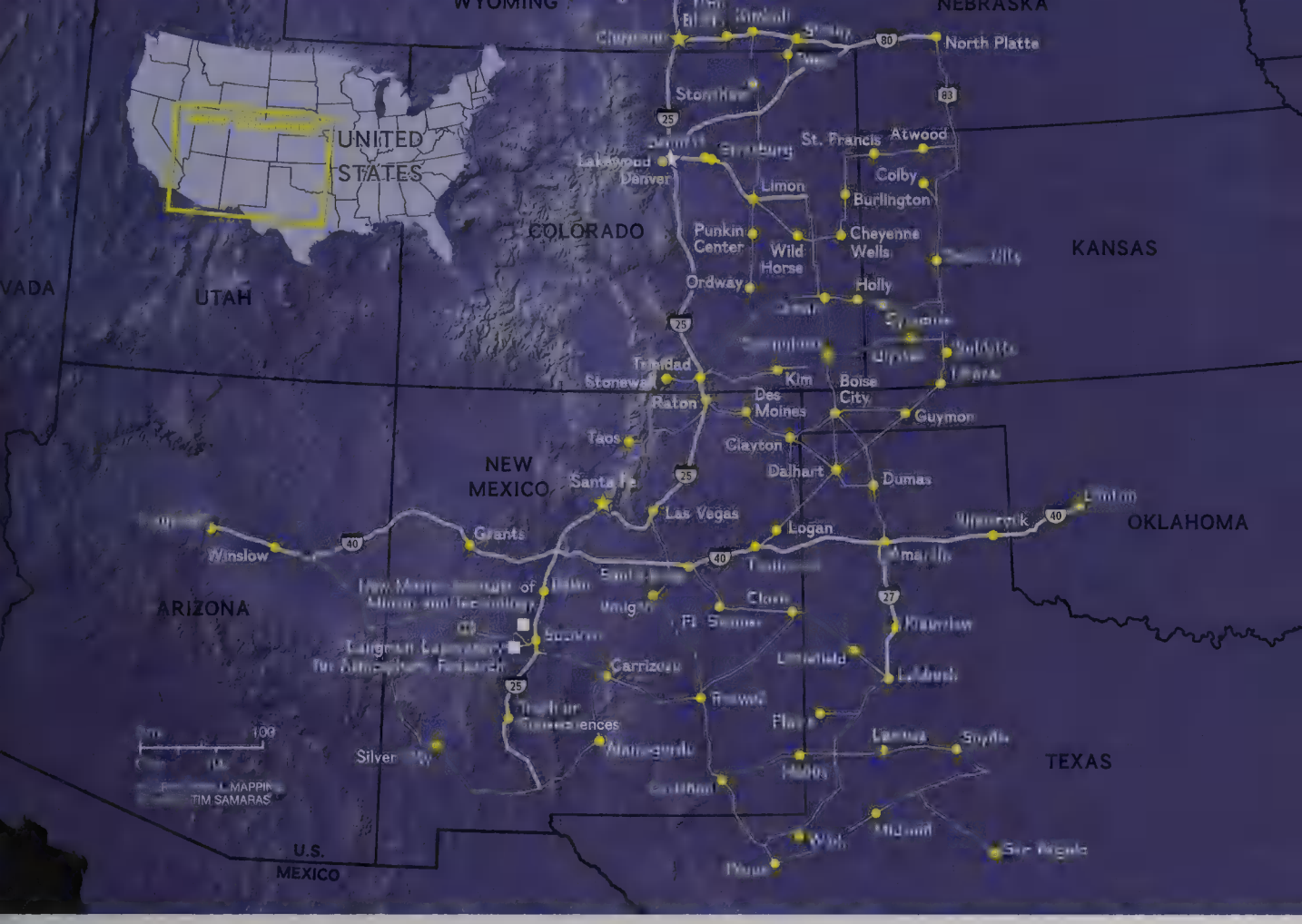
Built in 1963 by the New Mexico Institute of Mining and Technology in Socorro, the laboratory sits in the path of the monsoonal moisture that flows up each summer from the south. Sheltered inside an underground bunker called the Kiva, on South Baldy peak, a researcher remotely fires rockets, each connected to a long wire, into a highly charged storm cloud. Colleagues record the strike with a Phantom and other instruments in a building called the Annex, a mile away.

Bill Winn, head of the lab, seemed as skeptical about Samaras's approach as Samaras was of triggered lightning. ("Isn't he just interested in pretty pictures?" Winn had asked me earlier.) But the two men greeted each other cordially.

"You should have been here today," Winn said. "We had three strikes."

"Figures," Samaras said. One of the scientists explained that when conditions were right, a rocket would be armed and a five-second countdown would begin—any longer and the storm might produce a natural flash out of range of their instruments. Samaras looked worried. Since the Kahuna took ten seconds to spin up to speed, he would have to idle the turbine at a loping pace to keep it from overheating, then crank it up before the countdown began.

The next day's weather was discouragingly calm, but the storm that arose on the third day justified the wait. By early afternoon seven red-centered blobs were registering on the radar—a potent weather system to our northeast headed right for us. By 3 p.m. rain was falling faster and faster, hardening briefly to hail. We retreated inside the trailer and watched out the back.




## THE TRAIL OF A HUNTER

**Between 2006 and 2011 Samaras logged more than 25,000 miles in his quest to capture the birth of a lightning strike. His work begins in late summer, when damp air masses surge north. Uplifted by mountains and desert heat, the moisture cools and condenses, generating potent thunderstorms.**

Thunder, lightning—then the radio call: "Kiva is arming rockets." One storm had a purple center now, the most intense. Bands of red and orange were passing in front of us.

While the Langmuir crew watched from the safety of the Annex, I huddled on the trailer floor, shifting my attention between the weather outside and its abstraction on the radar. Wind was rocking us back and forth. If it hadn't been for the anchor provided by the Kahuna, I thought the trailer might blow off the mountain. With another crack of the radio, the Kiva requested a launch window, and Samaras began idling the turbine. Then, "Kiva launch in five." He ramped up the speed, and in the sky above us a rocket fired, its long, trailing wire instantly vaporized by lightning. But it happened too quickly. As Samaras had feared, the five-second window was too narrow. Over the next hour the Kiva fired five more rockets and triggered three strikes. But the Kahuna could not be readied in time.

Samaras left the mountain with some beautiful imagery from the Phantoms but once again without the long-awaited shot.

**WITH ANOTHER SEASON OVER,** Samaras retreated to a home he had recently purchased on a hill east of Denver overlooking the Colorado plains. But he is far from giving up the chase. He has installed an array of 12 computers to drastically reduce the Kahuna's download time. And with help from a government contract, he is building a "snorkel van" to house the camera, which will be attached to a periscope on the roof that can be nimbly turned in all directions. I would be surprised if he isn't out there now, one eye on the road and the other on a new storm throwing violent colors onto his laptop screen.

"I'm still in hot pursuit of that image," he told me. "And I won't stop until this is done." □

Back on the highway with the Kahuna in tow, Samaras hunts for the elusive shot. This summer he's on the chase again, with new, nimbler equipment.

114 These buyers paid dearly for a heap of fungus-infected larvae. Some go for $20 apiece.

# TIBETAN GOLD

A medicinal fungus highly prized in China is fueling a boom on the Tibetan Plateau.

Faces shielded from the sun, digging tools in hand, Tibetan families can search all day for the larvae, calle

*rtsa gunbu.* Some stalks poke barely a quarter inch out of the ground.

By Michael Finkel  Photographs by Michael Yamashita

# THE THING SILANG IS SEARCHING FOR, ON HANDS AND KNEES, 15,000 FEET ABOVE SEA LEVEL ON THE TIBETAN PLATEAU, IS EXTRAORDINARILY STRANGE.

The part that's above ground is a tiny, capless fungus—just a brown stalk, thin as a matchstick, poking an inch or two out of the muddy soil. Eleven hours a day, from early May to late June, Silang Yangpi and his wife and a large group of relatives and friends crawl along steep mountain slopes, combing through a dizzying tangle of grasses and twigs and wildflowers and sedge, seeking the elusive stalk.

When Silang spots one, he shouts with joy. His wife, Yangjin Namo, rushes over. Using a trowel, he carves around the stalk and carefully removes a wedge of soil. He brushes away the excess dirt. And there, in his palm, is what looks like a bright yellow caterpillar. Dead. Attached to its head, unicorn style, is the slender brown fungus. From his pocket Silang removes a red plastic bag that once held dehydrated ramen noodles. He places his find inside, along with the others he and his wife have unearthed, and carefully rolls the bag up. Silang is 25 years old; his wife is 21. They have an infant daughter. The caterpillar fungus represents a significant portion of their annual income.

Across the Tibetan Plateau, these creatures have transformed the rural economy. They've sparked a modern-day gold rush. In fact, by the time the contents of Silang's bag arrive at the gleaming shops of Beijing, they can easily be priced at more than twice their weight in gold.

The fungus is called *yartsa gunbu.* Translated from Tibetan, this means "summer grass, winter worm," although it is technically neither grass nor worm. It's the underground-dwelling larva of one of several species of the ghost moth that has been infected by spores from a parasitic fungus called *Ophiocordyceps sinensis.* The fungus devours the body of the caterpillar, leaving only the exoskeleton intact, and then, come spring, blooms in the form of a brown stalk, called the stroma, that erupts from the caterpillar's head. This process happens only in the fertile, high-alpine meadows of the Tibetan Plateau and the Himalaya. All attempts at farming the fungus have failed.

For centuries yartsa gunbu has been thought to possess miraculous medicinal and libidinous powers. Yaks that graze on it, legend holds, grow in strength tenfold. One of the earliest known descriptions of yartsa comes from a 15th-century Tibetan text, titled *An Ocean of Aphrodisiacal Qualities,* which raves about the "faultless treasure" that "bestows inconceivable advantages" on those who ingest it. Just boil a few in a cup of tea, or stew in a soup, or roast in a duck, and all that ails you will be healed—or so it's said.

The worms, as they're colloquially known, have been prescribed by herbalists to alleviate back pain, impotence, jaundice, and fatigue. Also to reduce cholesterol, increase stamina, and improve eyesight. To treat tuberculosis. And asthma. Bronchitis and hepatitis, anemia and emphysema. They're billed as an antitumor, antiviral antioxidant. A treatment for HIV/AIDS. A balm for those recovering from surgery. They may even help with hair loss.

As the Chinese economy roars, demand for yartsa has intensified—it's become a status symbol at dinner parties and the gift of choice to flatter government officials. In the 1970s a pound of worms cost a dollar or two. In the early '90s

---

*Michael Finkel reported on Greenland's dogsledders in the January issue. Michael Yamashita has shot dozens of stories in Asia for the magazine.*

A ten-year-old girl's gloved hand holds the tiny, dirt-covered biological curiosity: Yartsa gunbu is a combination of moth larva (caterpillar) and parasitic fungus. The high-priced "worms," as the infected larvae are called, are believed to cure everything from hair loss to hepatitis.

it was still less than a hundred dollars. Now a pound of top-quality yartsa can retail for $50,000.

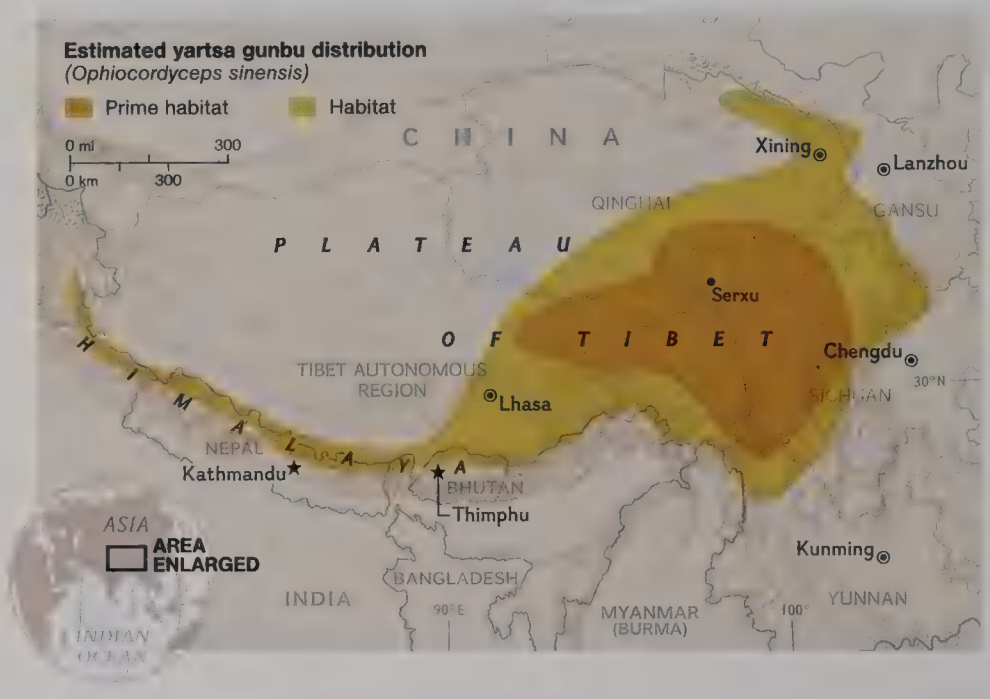
Such outsize demand sparks concern that the total annual harvest, now roughly 400 million specimens, may diminish as yartsa fields become overpicked. To harvest the worms sustainably, pickers would need to leave some stalks in the soil to mature and infect the next season's larvae, says ecologist Daniel Winkler. Instead, most villagers harvest every stalk they find and then move on to higher hunting grounds.

Due to the annual yartsa windfall, thousands of formerly impoverished Tibetan yak herders own motorcycles and iPhones and flat-screen TVs. Battles over worm-picking turf—most areas allow only licensed residents to pick—have resulted in violent encounters, including seven murders in northern Nepal, where a small percentage of the world's yartsa is picked. In the city of Chengdu, in Sichuan Province, burglars once tunneled, prison-break style, into a shop selling yartsa, making off with more than $1.5 million worth of product. The Chinese police have established numerous roadside checkpoints to prevent poachers from sneaking on to hillsides reserved for local villages.

There are now places, like the town of Serxu—home to Silang and his wife—where, when the ground warms and the grass sprouts, all else in life is abandoned to the pursuit of yartsa. Children, with keen eyes and low-to-the-ground statures, are often the best pickers. Some school systems, helpless against the lure of the worms, close for a one-month yartsa holiday.

At the end of the long picking day, Silang and Yangjin bring their worms to the local market. Serxu's market, during the height of the season, sprawls along the puddled sidewalks on both sides of the town's main street. It is customary, in this frontier-feeling place, amid treeless hills speckled with herdsmen's tents and strung with prayer flags, to dress up for market.

Many wear traditional Tibetan coats, the sleeves so long there's no need for gloves. Men




## WORM COUNTRY

Ghost moths and the fungus *Ophiocordyceps sinensis* thrive only at high altitudes (10,000-16,500 feet) and in moist soil, restricting yartsa gunbu's range. An estimated 96 percent of the world's harvest comes from the Tibetan Plateau. Experts worry that the current rate of harvest is unsustainable.

sport wide-brimmed cowboy hats and leather boots. Knives are strapped to waists. Smiles flash with gold teeth. Women strut about in necklaces strung with amber beads the size of golf balls. A few have braided hair that nearly sweeps the sidewalk. There are even a couple of monks, swaddled in vermilion robes. Religious strictures forbid them from picking or eating yartsa, but it's fine to buy and sell.

Yartsa dealers carry tiny brass-colored scales and solar-powered calculators. The sides of their hands are often smudged with jotted calculations. Worms are piled in cardboard boxes and wicker baskets or spread on pieces of cloth. When a dealer is approached by someone like Silang—knees muddy, with a bag of yartsa fresh from the fields—the worms are carefully examined. Their value depends on a number of factors: size, color, firmness. The dealer handles each one, often scraping off caked dirt with a special yartsa cleaning tool that looks like a large toothbrush. A crowd gathers.

It is also common practice, when preparing to make a purchase, for a yartsa dealer to keep up a steady patter of mild insults.

"I've never bought such bad worms."

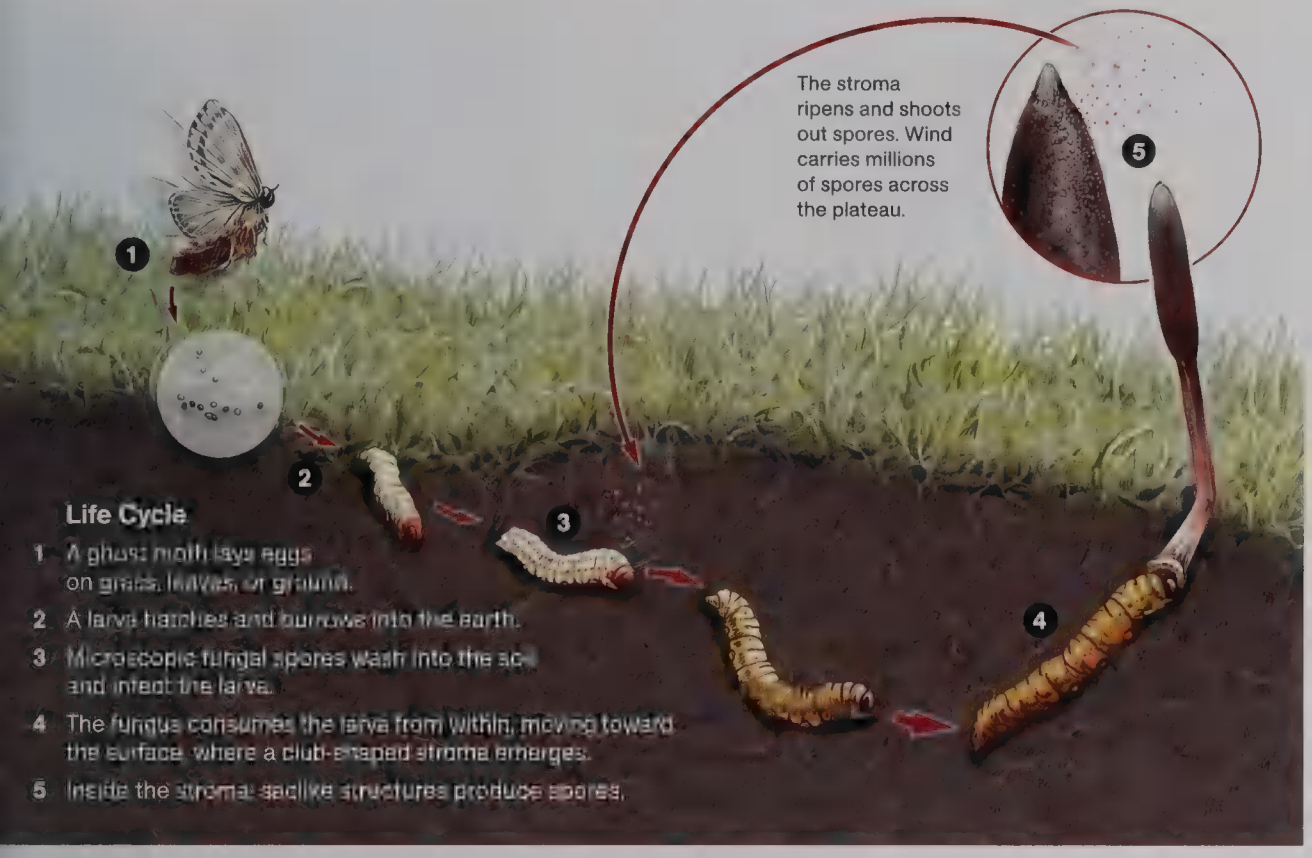
"The color's no good. Too dark."

"I'm going to lose money on these."

Finally, when it's time to do business, the dealer holds out his arm, the sleeve of his Tibetan coat dangling. The seller slips his hand inside. Then, using finger signals, the two haggle in the coat sleeve, shielded from the curious eyes of the crowd. It looks as if a thumb-wrestling match is going on in there—offers rapidly made and countered, the coat's fabric stretching and twisting. When the fingers settle and a price is agreed upon, the money is passed through the sleeve.

Silang and Yangjin approach a dealer they've worked with before, a man whose name is also Silang—Silang Yixi, 33, in business for eight years. He keeps photos of prized worms on his cell phone. The two Silangs conduct the ritual: the worm examination, the gibes—at one point the dealer returns the worms to the ramen bag and pretends he's no longer interested—and eventually the haggling. In the end, for their 30 worms, most too small to command top price, Silang and Yangjin are paid 580 yuan, about $90.

Zhaxicaiji steps from her chauffeur-driven Platinum Edition Toyota Sequoia, shoulders her Prada handbag, and strolls, high heels clicking, into the flagship store of her yartsa gunbu empire. She is founder and president of Three Rivers Source Medicine Company, one of


The stroma ripens and shoots out spores. Wind carries millions of spores across the plateau.
5
1
2
3
4
Life Cycle
1 A ghost moth lays eggs on grass, leaves, or ground.
2 A larva hatches and burrows into the earth.
3 Microscopic fungal spores wash into the soil and infect the larva.
4 The fungus consumes the larva from within, moving toward the surface, where a club-shaped stroma emerges.
5 Inside the stroma, saclike structures produce spores.

China's best known yartsa brands. She manages 500 employees and 20 stores; annual sales can top $60 million.

Growing up, Zhaxicaiji, who's now in her late 40s, was like Silang and Yangjin. She crawled in the hills, picking worms. Her family raised yaks and sheep and lived in a yak-hair tent. She started the business in 1998 with $120 of her own money and rode the yartsa juggernaut to success. She plans to expand internationally, exporting yartsa to places like Japan, Korea, and Malaysia. Within a decade, she says, her worms will be sold in the United States.

Her store in the central Chinese city of Lanzhou occupies a full city block; mounted over the entrance is a giant video screen playing commercials advertising her worms. Inside are opulent chandeliers, a trickling fountain, uniformed security guards, and vases of fresh-cut flowers. Her yartsa is exhibited in dozens of museum-style glass cases, the temperature and humidity precisely controlled.

Before a worm arrives here, it may change hands a half dozen or more times. Dealers in frontier markets sell to midsize markets, and those businessmen usually head to China's biggest yartsa market, which operates year-round, bustling and loud as a stock exchange, encompassing an entire district in Xining, a city just west of Zhaxicaiji's headquarters. Many of the largest, firmest, most ideally golden worms are selected by Zhaxicaiji's buyers. Prior to being put on display, all are x-rayed—it's become common to hide bits of lead wire in worms to increase weight.

A black Mercedes pulls up to her store and four middle-aged men, wearing polo shirts and chunky watches, take seats in front of one of the glass cases. They're promptly served by a staff of young women in dark skirts, white button-front shirts, and cotton gloves. The men munch on walnuts and raisins and drink yartsa-infused water as they make their selections. The worms are then neatly packaged in maroon wooden boxes with felt interiors and brass clasps, transforming a startlingly unattractive product—a faintly fishy-smelling Cheez Doodle-colored caterpillar with a strange growth emerging from its head—into something practically regal. The boxes are stacked in cloth shopping bags. In a matter of ten minutes the men spend $30,000.

On the fifth floor of a modern high-rise apartment building on the east side of Beijing, resting on her sofa and flanked by her bichons frises—Quan Quan (Little Circle) and Dian Dian (Little Dot)—Yu Jian sips a

MAP: JEROME N. COOKSON, NGM STAFF. ART: BONA KIM
SOURCES: DANIEL WINKLER, MUSHROAMING; YI-JIAN YAO, CHINESE ACADEMY OF SCIENCES

cup of freshly brewed yartsa gunbu tea. Yu is 40 years old; she's wearing a cheery flower-patterned blouse and leopard-print slippers. Until recently, she was an executive at a health food company. But in October 2010 she was diagnosed with uterine cancer.

She pursued a modern course of treatment, including extensive rounds of chemotherapy. But she also decided to visit a traditional Chinese herbalist. He prescribed yartsa. She's been using it for about six months.

Each evening she places two worms in a glass of water and lets it sit overnight. In the morning she boils the water along with some dried dates. She drinks the tea and then eats the softened worms. Yu buys only the highest quality yartsa, from the Tongrentang chain of pharmacies—one of the few brand names more famous, and more expensive, than Zhaxicaiji's. A bag of 24 midsize worms, enough to last a couple of weeks, costs her more than $550. "I think it's worth it," she says, though she is aware of the skepticism surrounding its effectiveness. So far the proof for the power of yartsa gunbu is not in.

Some studies, conducted primarily in China, reveal that it does contain an immune system modulator known as beta-glucan and an antiviral agent called cordycepin. A few clinical trials suggest it can help alleviate many of the conditions it's long been prescribed for, including bronchitis, asthma, diabetes, hepatitis, high cholesterol, and sexual dysfunction. But critics say the studies have been small and the methodology suspect.

"Until someone does a large clinical trial using a high-quality product, the science we have to rely on so far is not suggestive of a significant effect," says Brent Bauer, director of the Complementary and Integrative Medicine Program at the Mayo Clinic in Minnesota, who has extensively studied herbal medicines.

What's more, says mycologist Paul Stamets, wild yartsa may be tainted by any number of unidentified fungal molds, some of which might be harmful. "People could be poisoned," says Stamets, who has written six books on mushroom cultivation and sells his own mushroom products. "For the inexperienced, it is a form of Russian roulette." Whether the worms are a potent elixir or an exorbitantly expensive myth, there's little sign the yartsa gold rush will be over anytime soon. The evidence may be far from certain, but the belief is pervasive.

Yu Jian claims she can feel the worm's effect—both physically and psychologically. She says it improves her spirits and revitalizes her "life energy"—what's known in China as *qi* (pronounced chi). Her actual energy, though, can be variable.

Though she's quite thin, Yu does have a soft

ruddy color and a palpable vigor. On better days, it's easy to give the worms the credit. Other times, she's reminded that all cures, ancient and modern alike, have their limits. Yet on her most recent medical visit, she recalls, her doctor was shocked by the swiftness of her improvement. "He didn't even remember I was a cancer patient," she says. □

Every day during harvest season, Tibetan sellers arrive in Serxu with their batch of worms. Above, they dry them on one of the town's two streets, evaluating each: Is it undamaged and a good size? Does it have the desired yellow hue? Serxu's worms have a reputation for quality.

EPILOGUE *Since the reporting for this article was completed, Yu Jian's cancer turned virulent and ended up taking her life.*

Tibetan sellers negotiate with urban buyers, like the man at left in Serxu, following a predictable ritual:

uyers mock the quality of the worms. Sellers hawk their wares to many buyers before striking a deal.

Serxu is booming thanks to the growing yartsa gunbu trade. Many Tibetan harvesters arrive at the market

wn via motorcycles that are paid for with the profits.

Women sort, clean, and bundle fungal larvae at the Zhong Shi Caterpillar Fungus Hall in Chengdu. For 1,50

gh-quality worms—that's about two pounds—the firm could reap up to $100,000.

## NG CONNECT

Every month this page features our staff picks of National Geographic Society products and events. For more go to *nglive.org*.

### NATIONAL GEOGRAPHIC ON TV

## Dark Secrets of the *Lusitania*

Nicknamed the Greyhound of the Seas, the *Lusitania* (left) had its last run in 1915. Damaged by a German torpedo, then again by an unexplained explosion, the ship and most of its passengers sank off Ireland's coast. This month on the National Geographic Channel scientists visit the wreck, aiming to finally solve the mystery behind that second blast.

**EXHIBIT**

**CRITTERCAM** National Geographic's Crittercam technology reveals the secret lives of penguins, whales, bears, and more. Check it out and design your own Crittercam at the Discovery Place in Charlotte, North Carolina, through September 16. See *discoveryplace.org*.

**TRIP**

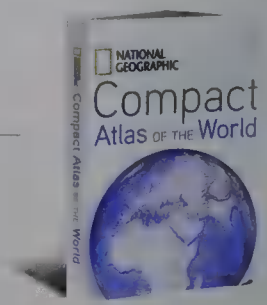
**ON SAFARI** Explore Africa on a National Geographic wildlife safari. Offerings include a trip by private aircraft to the Okavango Delta and Victoria Falls and a journey to Tanzania to view the legendary wildebeest migration, the Serengeti, Ngorongoro Crater, and more. The full list of safaris is at *ngexpeditions.com/safaris*.

**EVENT**

**BIOBLITZ** How many species live in Rocky Mountain National Park? Join the quest to tally them during this year's BioBlitz, happening on August 24 and 25. For more go to *nationalgeographic.com/bioblitz*.

**BOOK**

**PUT THE WORLD IN YOUR POCKET** More than a hundred maps and graphs fill National Geographic's first ever mini-atlas. Available in stores now, this small but mighty package holds a formidable amount of cartographic information ($14.95).




**Free Download of the Month**

**Forro in the Dark** *Light a Candle*

**Four New York–based Brazilian expats make up Forro in the Dark: Mauro Refosco, Davi Vieira, Guilherme Monteiro, and Jorge Continentino. The quartet is dedicated to updating *forró*, Brazil's version of country music, and bringing this traditional sound into the 21st century. To download ■ free song visit *natgeomusic.net/free*.**



PHOTOS: LIBRARY OF CONGRESS (TOP); WINFRIED WISNIEWSKI, FOTO NATURA/NATIONAL GEOGRAPHIC STOCK (CHEETAHS)

**Cover Potential** Photographer Aaron Huey was hanging out with young Wanahca Rowland and her cousin near Wounded Knee, South Dakota, when he had an idea. He asked the kids if they'd like to be on the cover of *National Geographic* and held up the mock yellow border he'd printed on a piece of acetate. For these girls—as well as other members of the tribe whose photos don't appear in the story—the frame generated smiles and, Huey hopes, a sense of inclusion. "It was a way that I could say, This is about you too." *—Catherine Zuckerman*

BEHIND THE LENS

## Why is this picture important to you?

**AH:** It represents the positive side of the Oglala world. There are happy people on the reservation. These girls, Wanahca Rowland (holding frame) and Nape Pejuta Win Rowland, live a free life out in the hills. Wanahca's mother is Olowan Thunder Hawk Martinez, who is leading an antialcohol campaign. Her house became a home base, of sorts, for me.

**How has your relationship with the people of Pine Ridge evolved?**

It started as a statistic. I was going to do a larger survey on poverty, and Pine Ridge was one of my stops because it had been one of the poorest counties in America for 30 years in ■ row. I didn't know much about treaties or any of the other issues when I first went out there in 2005. But I got sucked in and just couldn't believe what I was seeing, that this was real. Over time I became very close with ■ bunch of families; we call each other brother, sister. The evolution is incredibly complex, and I will definitely return. A few years ago I chose to take a side—their side—and to be not just a journalist but also an advocate.

**Mushroom Cap** This hat, shaped from the fibrous interior of *Fomes fomentarius,* was mailed to National Geographic headquarters by William J. O'Reardon in 1920. Its accompanying letter cataloged the cap's dimensions and alerted the editors that this "very rare and extraordinary cap [is] made from a mushroom."

The Latin *fomes* means "tinder," but it has long defied being just a fungus used to light fires. Up to a foot and a half long, the tree-encircling mushroom continues to be transformed into millinery today. According to an eyewitness report in the newsletter of the North American Mycological Association, *Fomes* caps of Hungarian origin were spotted for sale at the 12th International Fungi and Fibre Symposium in 2005. The attendee bought four. *—Johnna Rizzo*

**Flashback Archive** Find all the photos at **ngm.com.**

PHOTO: CHARLES MARTIN, NATIONAL GEOGRAPHIC STOCK

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**Marine Otter** *(Lontra felina)*
**Size:** Head and body length, averages approx. 55 cm (21.6 inches); tail, averages approx. 35 cm (13.8 inches) **Weight:** 3.2 - 5.8 kg (7.1 - 12.8 lbs) **Habitat:** Long patches of rocky shore, preferably with access to caves that remain above water at high tide **Surviving number:** Unknown; populations declining

*Photographed by Kevin Schafer*

# WILDLIFE AS CANON SEES IT

Adore the shore? The marine otter certainly does, spending 80% of the day at or near the rocky coastline before retiring to a den or refuge for the night. Females give birth in cave dens, with both parents then sharing the task of bringing back crustaceans, bivalves, octopuses and fish to feed their hungry families. Scientists believe the marine otter may be one of the most recent mammals to adapt to a marine habitat and lifestyle. But humans are also drawn to places where water meets land, and with humans come poaching, overexploitation of food resources, and dogs that prey on otters. The shore is becoming a dangerous place to be.

As we see it, we can help make the world a better place. Raising awareness of endangered species is just one of the ways we at Canon are taking action—for the good of the planet we call home. Visit **canon.com/environment** to learn more.

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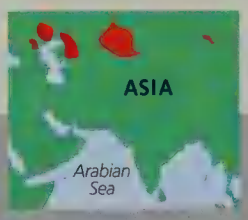


**Saiga** *(Saiga tatarica)*
**Size:** Head and body length, 108 - 146 cm (42.5 - 57.5 inches); shoulder height, 57 - 79 cm (22.4 - 31.1 inches); tail, 6 - 12 cm (2.4 - 4.7 inches) **Weight:** Males, approx. 41 kg (90 lbs); females, approx. 28 kg (62 lbs) **Habitat:** Prefers open dry steppe grassland and semi-desert areas **Surviving number:** Estimated at 100,000 - 110,000

*Photographed by Igor Shpilenok*

# WILDLIFE AS CANON SEES IT

Time traveler. The saiga is a relict species from the last ice age, evolutionarily distinct from other animals. Its unique nature is as plain as the nose on its face, which is thought to filter dust and warm the frigid air in the winter. This nomad has roamed the steppes for millennia, living in large herds when conditions allow. Thanks to a high birthrate, it has been able to bounce back following particularly brutal winters. But poaching—for meat and for the males' amber horns—has greatly intensified, recently decimating populations by 90%. Meanwhile, disease also threatens. Could the saiga's time be up?

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# NATIONAL GEOGRAPHIC

*"No matter how high you build up, everyone ends up in the grave."*
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Swimming in a thread of kelp, a harbor seal takes a break at a waterfront on the coast of San Diego. Story on page 66.

STEVE ÅKERRY

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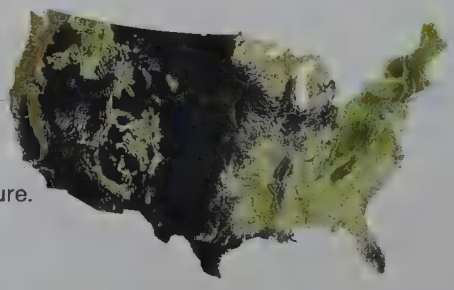

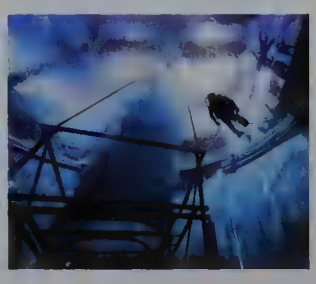


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EXCLUSIVE ON THE IPAD

**Dealing With Drought**
Video
*Meet the Texas farmers who won't give up.*

**Watery World**
Video
*Oceans pop out as a globe turns into a flat map.*

PHOTO: SPENCER MILLSAP, NGM STAFF. MAP: NGM STAFF

**On the Cover**
Storm chaser Hollingshead caught this 130-mile-an-hour tornado on June 20, 2011, near Bradshaw, Nebraska. At close range, he admits, "my heart tends to get up in my throat ■ little."
*Photo by Mike Hollingshead*

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PACK A SUITCASE,
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2X POINTS ON TRAVEL
WHY NOT PRETEND THAT FOR JUST THIS WEEKEND THERE'S NO SUCH THING AS WORK?
CHASE SAPPHIRE PREFERRED
D. WALDEN
CHASE

# The Coming Storms

The sky felt bigger and more dramatic when I lived in Kansas. I appreciated how it dominated the landscape, especially when supercell thunderstorms arrived in May and the afternoon horizon turned black or an eerie dark green. The atmosphere would explode in deafening thunder, blasts of lightning, and frightening winds. Tornado warning sirens shrieked, but I paid no attention as I watched the spectacle unfold. I was seldom alone. Others were drawn to witness the drama, despite the risk of being drowned by rain, pelted by hail, struck by lightning, blown into another county, or sucked up by a tornado.

**Clearly it is perilous to ignore the sky.**

Last year in the United States there were a record-breaking 14 extreme weather events—from floods to drought—that caused at least a billion dollars in damages each. There was loss of life as well. Clearly it is perilous to ignore the sky, as this month's cover story on extreme weather explains.

A tornado descends from a Kansas supercell.

Author Peter Miller knows this subject well. In the spring of 1986 he and I spent nearly three months chasing thunderstorms with a team from the National Severe Storms Laboratory for a story on tornadoes that ran in the June 1987 issue. Much has changed since then. Our planet has warmed up, there is more moisture in the atmosphere, heavy rains are more frequent, and droughts are more pronounced. Peter examines the causes and considers the future, which some say looks as ominous as a Kansas supercell in May.

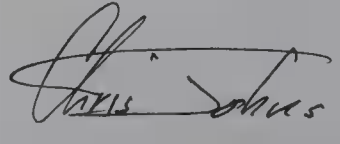



PHOTO: MIKE HOLLINGSHEAD, SCIENCE FACTION/GETTY IMAGES

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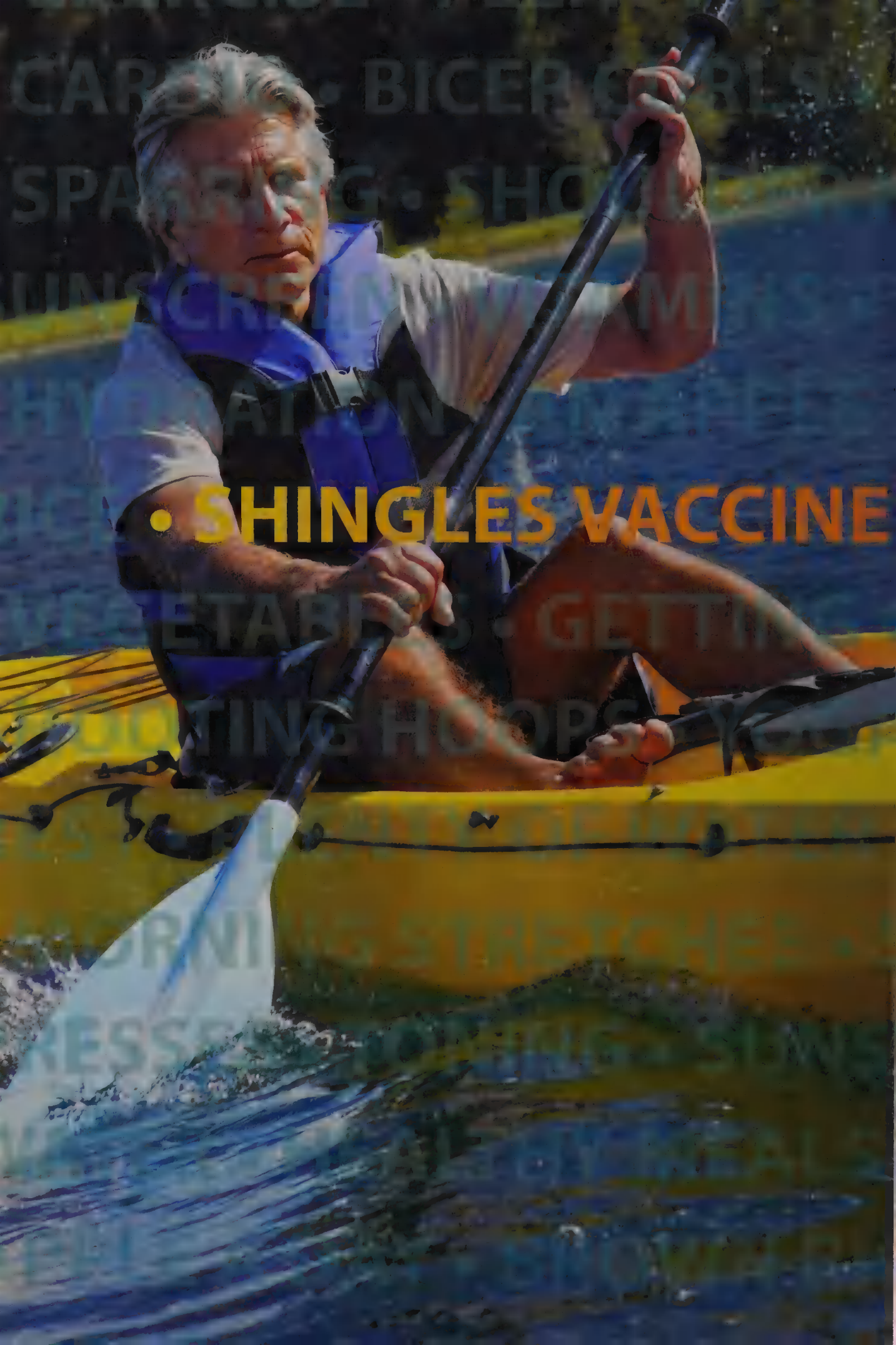
• SHINGLES VACCINE

# XPLORE. EXERT.
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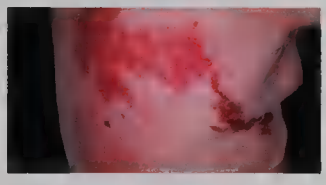
# UT DON'T FORGET TO VACCINATE.

## w's the time to help prevent Shingles with ZOSTAVAX® (Zoster Vaccine Live).



TAVAX is a vaccine that helps prevent Shingles in adults 50 years of age lder. Shingles is caused by the same virus that causes chickenpox. The s stays in your body and can resurface at any time as Shingles—a painful, tering rash. And no matter how healthy you feel, your risk increases as get older.

sooner you get vaccinated with ZOSTAVAX, the better your chances of tecting yourself from Shingles. In fact, the ACIP* of the CDC (Centers for Disease Control and Prevention) ommends that appropriate adults 60 years of age and older get vaccinated to help prevent Shingles.

## lk to your health care professional to see if ZOSTAVAX is right for you.

TAVAX is given as a single shot. ZOSTAVAX cannot be used to treat Shingles, or the nerve pain that may ow Shingles, once you have it. For more information, visit ZOSTAVAX.com or call 1-877-9 SHINGLES.

## OUT ZOSTAVAX

TAVAX is a vaccine that is used for adults 50 years of age or older to prevent Shingles (also known as zoster).

## portant Safety Information

OSTAVAX does not protect everyone, so some people who get the vaccine may still get Shingles.

ou should not get ZOSTAVAX if you are allergic to any of its ingredients, including gelatin or neomycin, ave a weakened immune system, take high doses of steroids, or are pregnant or plan to become regnant. You should not get ZOSTAVAX to prevent chickenpox.

lk to your health care professional if you plan to get ZOSTAVAX at the same time as PNEUMOVAX®23 neumococcal Vaccine Polyvalent) because it may be better to get these vaccines at least 4 weeks apart.

ssible side effects include redness, pain, itching, swelling, hard lump, warmth, or bruising at the jection site, as well as headache.

OSTAVAX contains a weakened chickenpox virus. Tell your health care professional if you will be in close ntact with newborn infants, someone who may be pregnant and has not had chickenpox or been ccinated against chickenpox, or someone who has problems with their immune system. Your health re professional can tell you what situations you may need to avoid.

are encouraged to report negative side effects of prescription drugs to the FDA. t www.fda.gov/medwatch or call 1-800-FDA-1088.

ase read the Patient Information on the adjacent page for more detailed information.

=Advisory Committee on Immunization Practices

## fore you get Shingles, get vaccinated.

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C-1016603-0025 05/12

# Patient Information about ZOSTAVAX® (pronounced "ZOS tah vax") Generic name: Zoster Vaccine Live

9989115

You should read this summary of information about ZOSTAVAX before you are vaccinated. If you have any questions about ZOSTAVAX after reading this page, you should ask your health care provider. This information does not take the place of talking about ZOSTAVAX with your doctor, nurse, or other health care provider. Only your health care provider can decide if ZOSTAVAX is right for you.

**What is ZOSTAVAX and how does it work?**

ZOSTAVAX is a vaccine that is used for adults 50 years of age or older to prevent shingles (also known as zoster).

ZOSTAVAX contains a weakened chickenpox virus (varicella-zoster virus).

ZOSTAVAX works by helping your immune system protect you from getting shingles.

If you do get shingles even though you have been vaccinated, ZOSTAVAX may help prevent the nerve pain that can follow shingles in some people. ZOSTAVAX does not protect everyone, so some people who get the vaccine may still get shingles.

ZOSTAVAX cannot be used to treat shingles, or the nerve pain that may follow shingles, once you have it.

**What do I need to know about shingles and the virus that causes it?**

Shingles is caused by the same virus that causes chickenpox. Once you have had chickenpox, the virus can stay in your nervous system for many years. For reasons that are not fully understood, the virus may become active again and give you shingles. Age and problems with the immune system may increase your chances of getting shingles.

Shingles is a rash that is usually on one side of the body. The rash begins as a cluster of small red spots that often blister. The rash can be painful. Shingles rashes usually last up to 30 days and, for most people, the pain associated with the rash lessens as it heals.

**Who should not get ZOSTAVAX?**

You should not get ZOSTAVAX if you:

- are allergic to any of its ingredients.
- are allergic to gelatin or neomycin.
- have a weakened immune system (for example, an immune deficiency, leukemia, lymphoma, or HIV/AIDS).
- take high doses of steroids by injection or by mouth.
- are pregnant or plan to get pregnant.

You should not get ZOSTAVAX to prevent chickenpox.

Children should not get ZOSTAVAX.

**How is ZOSTAVAX given?**

ZOSTAVAX is given as a single dose by injection under the skin.

**What should I tell my health care provider before I get ZOSTAVAX?**

You should tell your health care provider if you:

- have or have had any medical problems.
- take any medicines, including non-prescription medicines, and dietary supplements.
- have any allergies, including allergies to neomycin or gelatin.
- had an allergic reaction to another vaccine.
- are pregnant or plan to become pregnant.
- are breast-feeding.

Tell your health care provider if you expect to be in close contact (including household contact) with newborn infants, someone who may be pregnant and has not had chickenpox or been vaccinated against chickenpox, or someone who has problems with their immune system. Your health care provider can tell you what situations you may need to avoid.

**Can I get ZOSTAVAX with other vaccines?**

Talk to your health care provider if you plan to get ZOSTAVAX at the same time as the flu vaccine.

Talk to your health care provider if you plan to get ZOSTAVAX at the same time as PNEUMOVAX®23 (Pneumococcal Vaccine Polyvalent) because it may be better to get these vaccines at least 4 weeks apart.

**What are the possible side effects of ZOSTAVAX?**

The most common side effects that people in the clinical studies reported after receiving the vaccine include:

- redness, pain, itching, swelling, hard lump, warmth, or bruising where the shot was given.
- headache

The following additional side effects have been reported with ZOSTAVAX:

- allergic reactions, which may be serious and may include difficulty in breathing or swallowing. If you have an allergic reaction, call your doctor right away.
- chickenpox
- fever
- hives at the injection site
- joint pain
- muscle pain
- nausea
- rash
- rash at the injection site
- swollen glands near the injection site (that may last a few days to a few weeks)

Tell your health care provider if you have any new or unusual symptoms after you receive ZOSTAVAX. For a complete list of side effects, ask your health care provider.

Call 1-800-986-8999 to report any exposure to ZOSTAVAX during pregnancy.

**What are the ingredients of ZOSTAVAX?**

Active Ingredient: a weakened form of the varicella-zoster virus.

Inactive Ingredients: sucrose, hydrolyzed porcine gelatin, sodium chloride, monosodium L-glutamate, sodium phosphate dibasic, potassium phosphate monobasic, potassium chloride.

This page summarizes important information about ZOSTAVAX. If you would like more information, talk to your health care provider or visit the website at www.ZOSTAVAX.com or call 1-800-622-4477.

**Rx only**

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NATIONAL GEOGRAPHIC

# *Inspire* Future Generations

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Former U.S. Marine and aviation engineer, J.C. and his wife Ann, have had *National Geographic* magazine in their home since 1950. "We rely on *National Geographic* as a source of timely, current, and balanced reporting," says J.C. "We love the wide-ranging topics, international scope and that the information is accessible to everyone young and old alike. We are proud to be sending our great-granddaughter Isabella the children's edition. Your stories have a unique cross-generational reach and appeal."

"When we reviewed our long-term charitable plans, we created a stand-alone Charitable Remainder Unitrust in which National Geographic is the major beneficiary. It is our way to ensure that future generations will be able to explore our amazing world and universe. We would encourage others who have charitable trusts or are planning on setting one up to think of including National Geographic. Your gift, like ours, will be well used and make a real difference."

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Photo: John Joseph van Haelewyn

## Civil War

Why was not some mention made of the young boys who were involved in the Civil War? One of my relatives was one of those boys. He was a ten-year-old named John Joseph Klem (born Newark, Ohio, 1851) who served with the 12th and 22nd Michigan Volunteers. During the Battle of Shiloh his drum was shattered by an artillery round. During the Battle of Chickamauga, in 1863, while riding a caisson, he shot a Confederate who tried to stop him. This earned him the name Little Drummer Boy of Chickamauga. Maybe some future writings will reflect the young boys' contributions.

**YURBA E. HILLYER MILLER**
**Redding, California**

Harry Katz describes how dangerous the work of a sketch artist was during the Civil War, including Anglo-Italian Frank Vizetelly's experience at First Bull Run. Having survived Garibaldi's campaigns in Europe and his time in America, Vizetelly eventually went a campaign too far. He is believed to have been killed on November 5, 1883, at the Battle of Shaikan in the Sudan while marching with Hicks Pasha's expedition against the Mahdi. The risks are perhaps greater for today's war photographers. The need to understand through visualization is still great.

**ALAN WATERS**
**Braintree, England**

No matter how carefully the reenactment is done, one crucial character is always left out: Death. The late George Carlin said anyone wanting to reenact a battle should use live ammunition.

**STEVEN SABOTTA**
**Fukuoka, Japan**

Before Abe said it, Jesus did: "If a house is divided against itself, that house will not be able to stand" (Mark 3:25, et alia).

**FERNANDO MIGNONE**
**Burnaby, British Columbia**

*When Abraham Lincoln accepted the nomination to be Illinois's Republican candidate for U.S. Senate in 1858, he used Jesus' words in his speech without attribution, knowing his audience would understand whom he was quoting. He didn't have to add, "as Jesus said to the Pharisees."*

The photos were excellent in simulating the technology of the mid-19th century and in showing the meticulously attired figures, but were set up for ridicule by the inclusion of artifacts of modern-day life.

**WILLIAM LEAHY**
**New Forest, England**

**Corrections**
MAY 2012, CIVIL WAR POSTER
Austin C. Wellington should have been identified as a corporal, not a private.

**FEEDBACK** *Readers reacted to our coverage of the hazards koalas face in today's Australia.*

"It was [illegible] read [illegible] plight [illegible] koalas [illegible] feelings [illegible] horror."

"I never dreamt [illegible] Australia's beloved [illegible] bear [illegible] threatened."

"My wife, my college-age daughters, and I feel that the dead koalas picture was totally unnecessary."

"Thank you for raising [illegible] about the threats to Australia's koalas."

"Never [illegible] has a mere photograph moved me to tears like the one Joel Sartore took [illegible] the deceased koalas."

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GRAPHIC: ÁLVARO VALIÑO

# How to Outsmart a Millionaire

*Only the "Robin Hood of Watchmakers" can steal the spotlight from a luxury legend for under $200!*

Mr. Bigshot rolled up in a roaring high-performance Italian sports car, dropping attitude like his $22,000 watch made it okay for him to be rude. That's when I decided to roll up my sleeves and teach him a lesson.

"Nice watch," I said, pointing to his and holding up mine. He nodded like we belonged to the same club. We did, but he literally paid 100 times more for his membership. Bigshot bragged about his five-figure purchase, a luxury heavyweight from the titan of high-priced timepieces. I told him that mine was the ***Stauer Corso, a 27-jewel automatic classic now available for only $179.*** And just like that, the man was at a loss for words.

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The Stauer ***Corso*** is proof that the worth of a watch doesn't depend on the size of its price tag. Our factory spent over $40 million on Swiss-made machinery to insure the highest quality parts. Each timepiece takes six months and over 200 individual precision parts to create the complex assembly. Peer through the exhibition back to see the 27-jeweled automatic movement in action and you'll understand why we can only offer the ***Corso*** in a limited edition.

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# VISIONS

**Indonesia**
Empty-handed after a trip to a feeding area, Duyuk the orangutan hangs out in Borneo's Tanjung Puting National Park. The rehabilitated primate was released into the wild some 20 years ago but occasionally returns for a bit of banana and milk.

[illegible] WILL SHAH, NATURE PICTURE LIBRARY

China
A Mongol boy s ebu
bounce bubbles over on a
traditional swim mac
of rope and a pillow seat.
The akemnon flight takes
place under the brother
dusky land in Hein a
rural village in the north
west region of Xinjiang.
PHOTO

**United States**
A chocolate chip cookie tempts a wild raccoon from the forest to the steps of a bed-and-breakfast near the Oregon coast. In the Pacific Northwest the mostly nocturnal mammals typically range between 10 and 25 pounds.

PHOTO: GOREY ARNOLD

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This page features two photographs: one chosen by our editors and one chosen by our readers via online voting. For more information, go to *ngm.com/yourshot*.

EDITORS' CHOICE **Romeo Doneza** Long Beach, California

The scene: Sunday morning at Hilltop Park, in the city of Signal Hill. Doneza, 57, waits for a man and his dog to pass by and meld with a concrete sculpture. The painted shadows of an oil derrick and worker commemorate the area's oil-rich history.

READERS' CHOICE

**Blerta Zabërgja**
Prishtina, Kosovo

Zabërgja was 22 when she watched this sunset from a rooftop. "I was feeling like Alice in Wonderland, all grown up and facing the chaos of the real world!" says the painter and photographer, now 28. "I love heights and took this self-portrait to capture the feeling it gives me."

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September 22
Autumnal equinox

## Spring Awakening

In the 50 years since marine biologist Rachel Carson's *Silent Spring* was published, the Environmental Protection Agency was born and the U.S. has tightened its use and regulation of toxic chemicals. The 1962 classic focused on the pesticide DDT's alarming effects on wildlife and its longevity in the food chain. Scientists blamed the dramatic decline of bald eagles on their consumption of DDT-laden prey, which caused some bird species to produce ultrafragile eggs.

*Silent Spring* is often cited as the primary reason the EPA banned DDT in 1972. While Carson, who died in 1964, urged more cautious use of pesticides, she didn't advocate specific policies, says biographer Linda Lear. Environmental historian Thomas Dunlap notes the book prompted research that led to major policy shifts, such as increased oversight of federal projects and a 1972 overhaul of regulations on the sale and use of all pesticides. "She was the catalyst for the modern environmental movement," says Dunlap, "and in that sense we are all children of Carson." —*John Briley*

PHOTO [illegible] SPARROW NEST AND [illegible] STAFF

# An Unlikely Leprosy Link

The armadillo did it. That's what an international team of researchers says after its DNA detective work solved a medical mystery: how dozens of people in the U.S. contract leprosy each year without having traveled to countries where it's more common. Genetic sequencing now shows that humans and armadillos in the American South share a unique strain of the bacterium behind leprosy, aka Hansen's disease.

The infection—which can lie dormant for years before causing skin lesions, nerve damage, and muscle weakness—was thought to pass only from person to person. The new research indicates it can move from the armored mammals, whose cool body temperature (89°F) makes them a prime host, to people who hunt, cook, or handle them.

Richard Truman of the National Hansen's Disease Program says an armadillo-leprosy link had long been suspected. Though the risk to people remains low—only 5 percent of us are genetically susceptible to the malady—Truman urges U.S. doctors to consider leprosy during diagnoses. His advice for everyone else: "Don't touch armadillos." *—Jeremy Berlin*

## About Leprosy

250,000 new cases of leprosy arise worldwide each year. Nine-banded armadillos (below) are the only animals other than humans known to carry the disease.

The disease can't be spread by handshakes or sexual intercourse. Bacteria are believed to enter the body through cuts or mucous membranes.

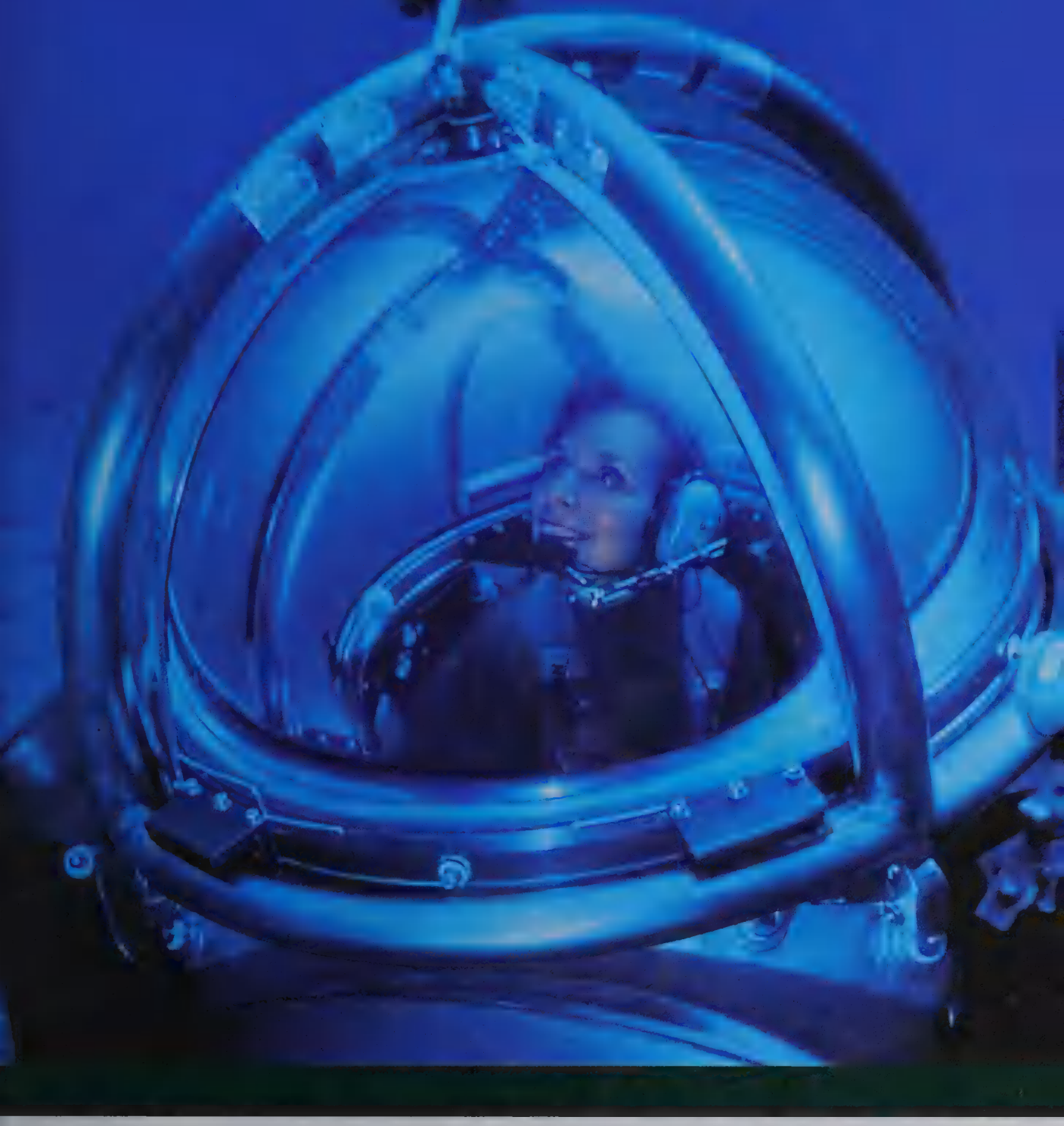
The "biblical plague" aspect—like fingers and toes falling off—is mostly a myth in today's world, where treatment is available, says Anthony Fauci of the National Institute of Allergy and Infectious Diseases. "Deformities can occur, but by then it involves decades of untreated disease."

A cocktail of three antibiotics cures nearly all cases detected early.

Twenty percent of nine-banded armadillos in parts of the southern U.S. have leprosy.

Established U.S. range of the nine-banded armadillo

PHOTO: JOEL SARTORE, NATIONAL GEOGRAPHIC STOCK. NGM MAPS
SOURCE: W. J. LOUGHRY, VALDOSTA STATE UNIVERSITY



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At rest, humans use 20 percent of our food energy to fuel the brain.

# Rank and Vile

Botanist Greg Wahlert is crying foul. A new *Amorphophallus* species he collected—a relative of the corpse flower and voodoo lily—reeks of cheese as it grows, shooting up inches a day until it reaches roughly four feet. "Then, at the height of its glory, when it's pumping out phytochemicals, it smells like feces and rotting flesh," says Wahlert. Other researchers have cataloged some of the 170 known species of *Amorphophallus* according to odor: fishy/urine; dung/feces; carrion; rancid cheese; or surprisingly, spicy/fruity/chocolaty (including a species in Japan harvested for candies).

Wahlert plans a full botanical inventory of Nosy Ankarea—the island off the coast of Madagascar where he collected the stinky specimen—and he's hopeful that its flora won't be lost to human development. The island is uninhabited and part of an archipelago safeguarded by the Antankarana people. "Those plants have a real shot in the long term, because the Antankarana are protective of their culture," says Wahlert. "It's an interesting example of conservation."

*—Johnna Rizzo*

*This yet-to-be-named* Amorphophallus *species blooms once a year in the thin basaltic soil of Nosy Ankarea.*

PHOTO: CAMERON MCINTIRE, UNIVERSITY OF UTAH
TOP GRAPHIC: ÁLVARO VALIÑO. SOURCE: DAVID LEVITSKY, CORNELL UNIVERSITY. BOTTOM GRAPHIC: NGM ART. NGM MAPS

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# Frank Rankings

Ranking cities for "livability" grows more complicated each year. Just think of the urban scene in 2011: violent protests in Athens and elsewhere over economic issues, continuing unrest in Arab capitals, terrorist attacks on government buildings in Oslo and a summer camp nearby. All that strife prompted Mercer, a human resources consultancy, to add a separate personal safety section to its annual ranking of more than 200 cities, which helps companies determine cost of living adjustments for employees transferred overseas. Baghdad ranked dead last overall; Luxembourg was first for safety, due to a low crime rate and stable political situation.

Mercer weighs many factors in its overall rankings (right): education, public health, censorship, mass transit, culture. Economists and other rankers take a different tack. The Cato Institute's urban planning expert Randal O'Toole favors looking at which cities draw the most newcomers. To him, that's a sign of affordable, livable cities. He reports that in the U.S., Houston, Dallas, and Atlanta are tops. *—Catherine Zuckerman*

*Numbers add up to 32 because of ties.

GRAPHIC: LAWSON PARKER, NGM STAFF
SOURCE: MERCER CONSULTING

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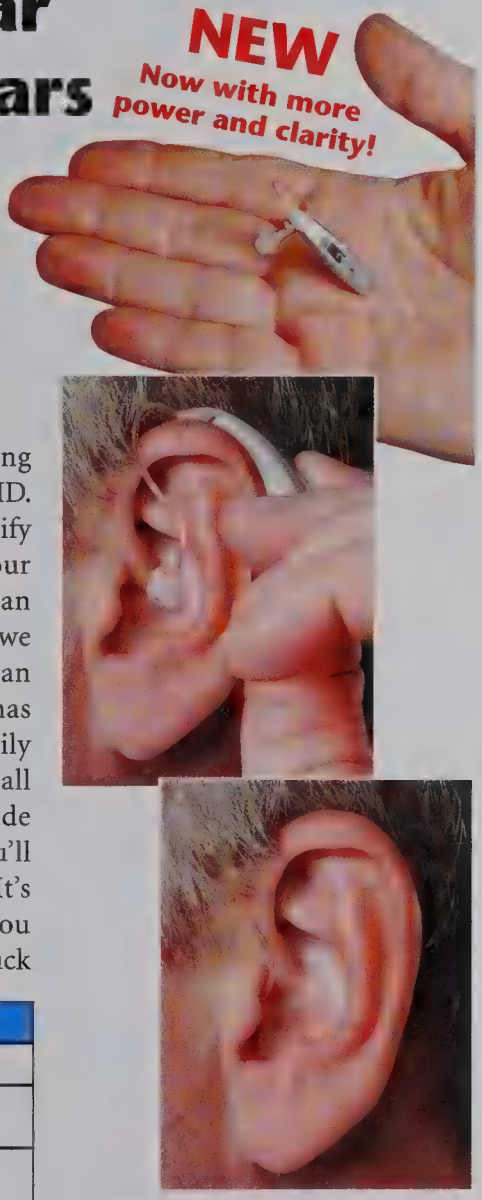
## Sweeping the Sky

At dusk in winter the sky above Rome fills with hundreds of thousands of European starlings moving and twisting like a giant, single organism. Such avian displays have long mystified human observers; one British naturalist believed the birds used a kind of telepathy to move in sync.

Italian physicist Irene Giardina and colleagues concluded that each starling's movement directly affects six or seven neighbors. Now they've measured the strength of these interactions. Just as metallic atoms align to create a magnet, the effect ripples across the entire flock almost instantaneously. Still unknown: why the birds gather like insect swarms in the first place. Some scientists surmise that the massive gyrations help protect individuals from predators. But then, Giardina wonders, "why wouldn't they remain in trees rather than dance in the sky?" *—Luna Shyr*

PHOTO: RICHARD BARNES

# The invention of the year is great news for your ears

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A human skeleton has 300 bones at birth but only 206 by adulthood.

*One 2009 estimate placed 800,000 snake charmers in India—like this one in New Delhi, with a king cobra.*

## Charms and Chips

It's a culture clash for the ages: mystic snake charmers versus high-tech bureaucrats. Last year 43 snakes—cobra, python, rat snake, boa—owned by ten Delhi charmers were implanted with ID microchips. Officials hope the procedure will, among other things, help them keep tabs on who owns which snakes. Noncompliant charmers, who call the measure unfair, could be jailed.

Yet even chipped snakes are illegal based on a 1972 law, says Kartick Satyanarayan of Wildlife SOS. He urges reform, not regulation: Instead of defanging and mistreating snakes, charmers could use their skills for conservation work. Herpetologist Romulus Whitaker agrees, but wonders about widespread change. Snake charming has largely left urban India, he says, though in superstition-steeped rural areas, "it's not going away for the next hundred years." *—Jeremy Berlin*

**IT CAME FROM OUTER SPACE** Is it possible to get hit by something falling from orbit? It's happened only once, but NASA estimates that man-made debris lands on Earth nearly every week—mostly in water. Debris can be anything from the fiberglass rocket scrap that struck an Oklahoma woman in 1997 (she was fine) to the 350-pound satellite chunk that fell into the Pacific last year. Orbital junk is under constant watch, and no one's been hurt in 50-plus years. "It's amazing but statistically consistent," says NASA's Nick Johnson. "The world's a big place." *—Luna Shyr*

PHOTO: MATTIAS KLUM. GRAPHICS: ÁLVARO VALIÑO

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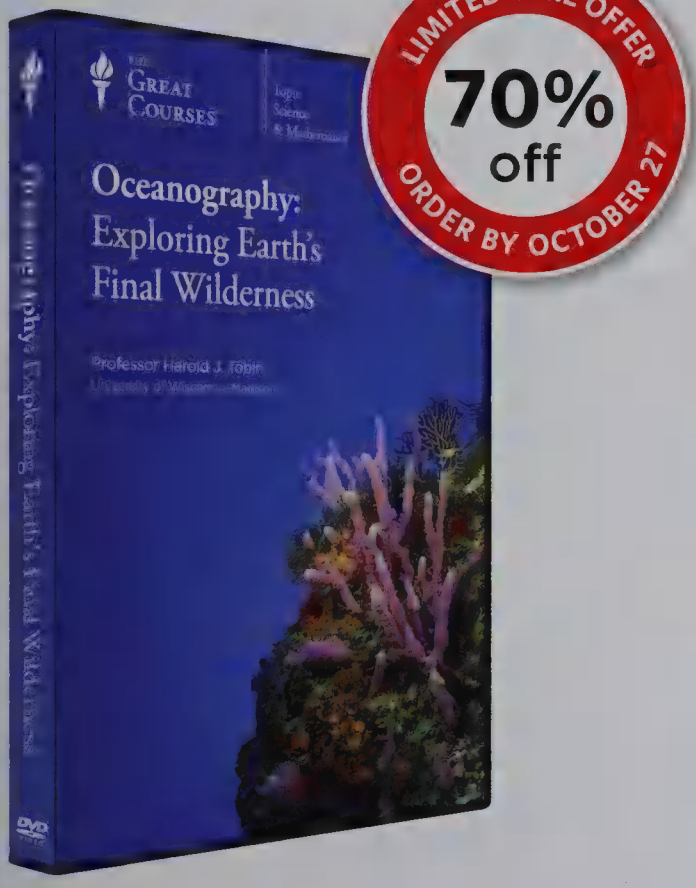


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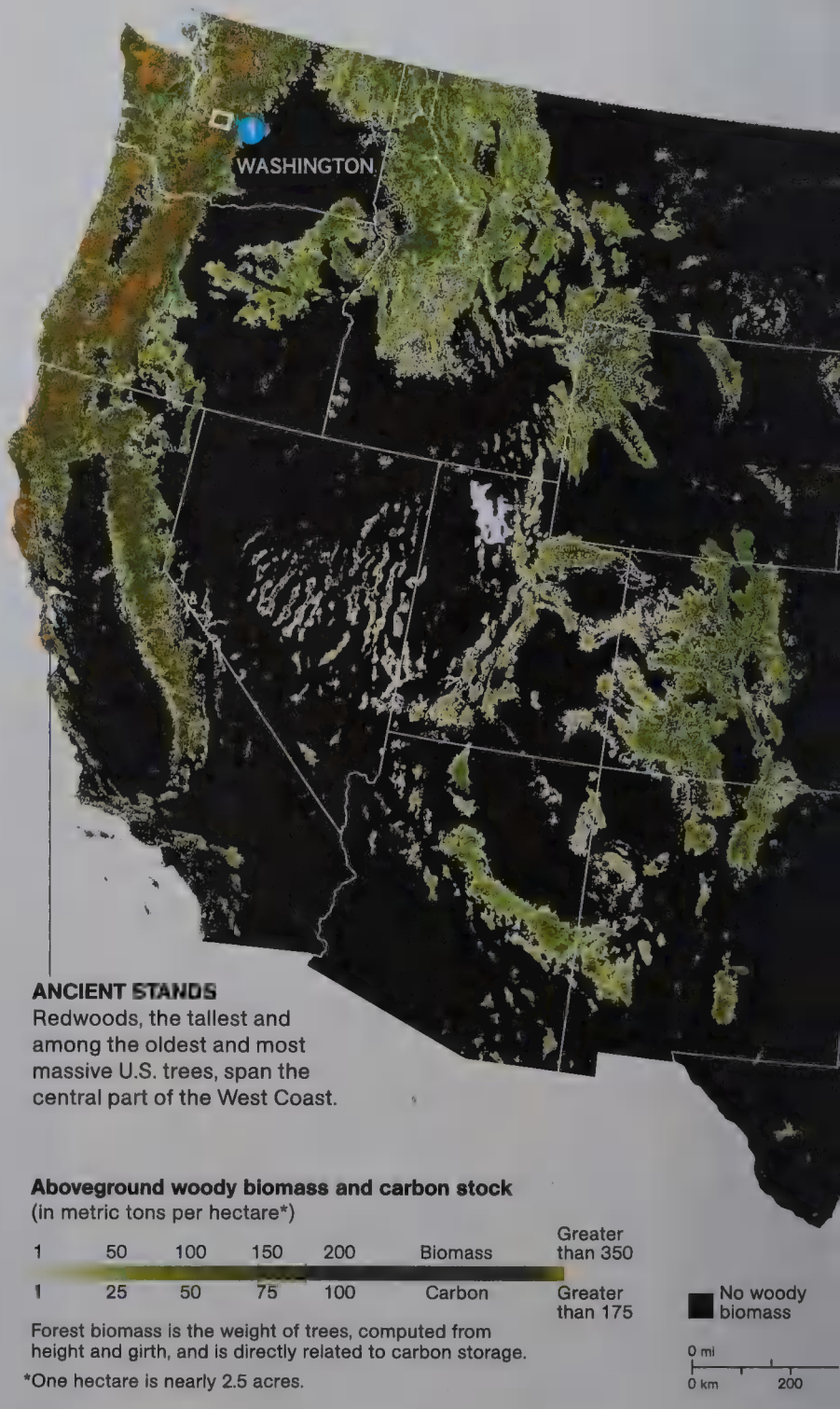
# NEXT

# American forests tell the history—and likely future—of human habitation.

## WHISPERING PINES

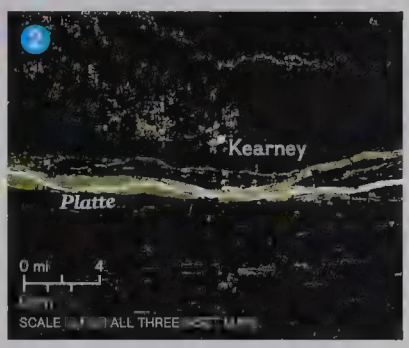
WHEN RADAR ON BOARD the space shuttle measured treetop instead of ground elevation, geologists were disappointed. Forest researchers weren't. "One scientist's noise is another's data," points out Josef Kellndorfer of the Woods Hole Research Center. With colleague Wayne Walker, he combined the treetop data with computer models and tree surveys to build the first high-definition map of U.S. forest biomass. It boasts pixels showing areas the size of a baseball infield.

There's a lot more to the forests than the trees—the map says as much about the people who live among them. In the timber-rich West straight-edged scars reveal the work of loggers. Sparse woods in the Midwest tell of farmers who planted trees on the prairie for building supplies. The East's stands relate the success story of reforestation centuries after colonists stripped the land. Today's land managers are translating the map's shades of green into timber resources, forest fire risk, and 13 billion tons of carbon storage. Says Kellndorfer, "The map is an inventory of history and our future." *—Juli Berwald*




**ANCIENT STANDS**
Redwoods, the tallest and among the oldest and most massive U.S. trees, span the central part of the West Coast.

President Lincoln's exchange of square plots for railroad track led to checkerboard logging in the West.




Belts of forest straddle rivers surrounded by farms dug into the nearly treeless Midwestern prairie.

Cities like Bangor, Maine, inch into postcolonial regrowth that covers 80 percent of New England.

**FOREST BANDS**
Development proceeded in stripes along the Appalachian range. Woods remain on slopes too steep for building.

**TREE FARMS**
In the Southeast fast-growing trees are planted as crops. Some softwoods, like pine, are harvested every 20 years.

**RICH FLOODPLAINS**
The Mississippi River fertilizes a wide corridor where forests give way to corn, cotton, and soybean fields.

MAP: JEROME N. COOKSON, NGM STAFF; GREG FISKE, WOODS HOLE RESEARCH CENTER; THEODORE A. SICKLEY. SOURCES: NASA; U.S. FOREST SERVICE; USGS

# Rolling Robo-Worm

Stop, drop, and roll. Firefighters teach this to kids, but for some species of caterpillars it's a defense reflex. Confronted by a predator, the larvae spring into the air, assume a spiral shape, and hit the ground at top speed to wheel away from danger. The motion is thought to be one of the fastest wheeling behaviors in nature.

Hoping the technique will enable next-generation robots to go places that conventional crawling ones can't, researchers at Tufts University have built a soft-bodied robot that replicates the spiraling actions of larval *Pleuroptya ruralis*, a species from the U.K. Made of silicone rubber, the robot's four-inch-long body (below) is undergirded by metal coils that contract into a circle when electrified, propelling the contraption forward at nearly eight inches a second.

As in nature, the ballistic rolling motion can send the body in unpredictable directions. But, says lead researcher Huai-Ti Lin, the robot's ability to crawl or roll, depending on terrain, could one day have practical applications in environmental monitoring, building inspection, or even disaster search and rescue. *–Bruce Falconer*

*In less than half a second, this caterpillar-inspired robot springs into a spiral—a defensive move in nature.*

Watch the robot in action in a video on the iPad.

PHOTOS: CARY [illegible] AND [illegible]

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Food demand is expected to rise some 70 percent by 2050. To help meet the need, the next green revolution is focused on aiding small farmers.

# Precious Water

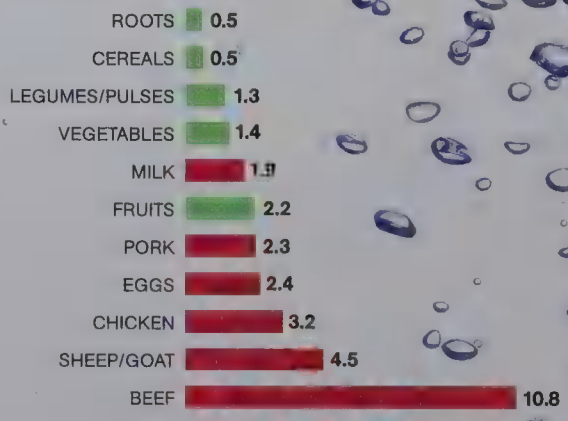
Many farmers already struggle to get enough water for their crops. Foods like beef, which people crave as they become more affluent, take far more water to produce than fish or plants. Water-efficient techniques like drip irrigation, conservation tillage, and mulching help make the most of a dwindling resource. New, less thirsty varieties of crops will help too. But ultimately we will have to learn to sip where we once gulped. *—Nancy Shute*

AGRICULTURE ACCOUNTS FOR **92%** OF HUMANITY'S WATER FOOTPRINT

## WATER COSTS

Animal production (in red) requires large volumes of water for feed, drinking water, and maintenance.

**Water footprint* per unit of nutritional value,** *quarts/kcal*




*Defined as the total volume of fresh water used to produce each item

PHOTO: REBECCA HALE, NGM STAFF. GRAPHIC: JASON TREAT, NGM STAFF
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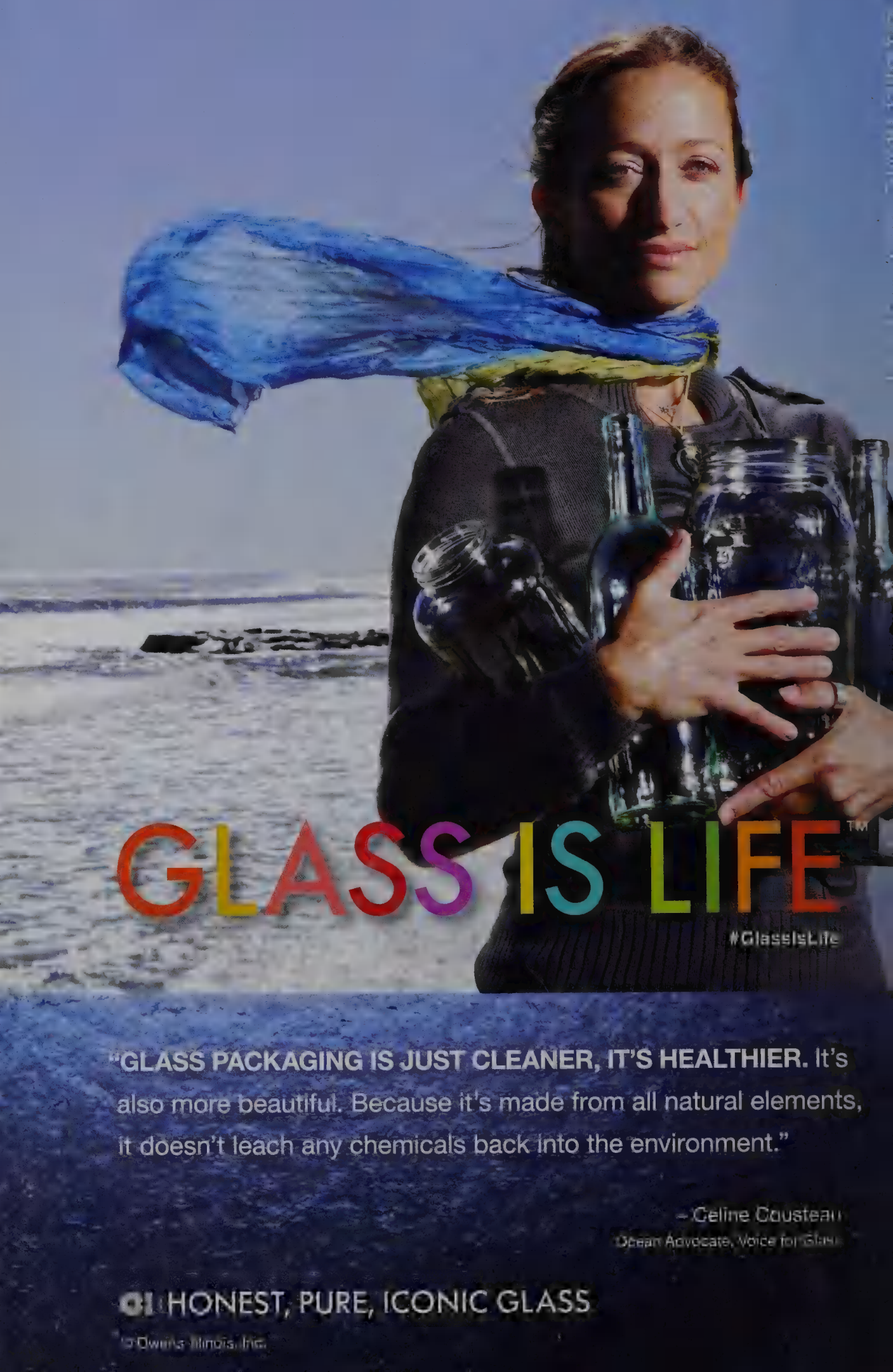


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– Celine Cousteau
Ocean Advocate, Voice for Glass

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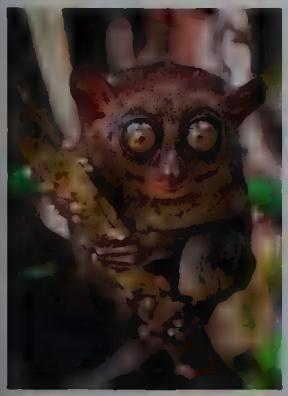
The average circulation time for U.S. dollar bills varies by denomination.

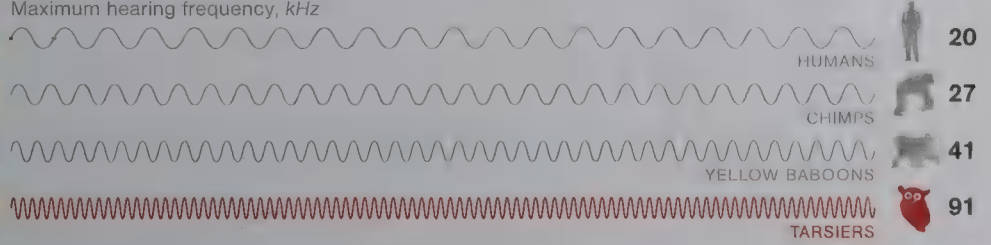
## Surround Sound

Blue whales have the loudest voices of any living thing. Pile drivers are louder. Acousticians at the University of Texas have a way to dim underwater industrial noise and conserve whale chatter: surround machinery with a curtain of bubbles that can cut 40 decibels off the din of bridge building or oil drilling, dampening the equivalent of a city street's noise to a library's.

The premise: Ramming into bubbles saps a sound wave's energy. Early tests used traditional bubbles, but the final formula uses air encased in plastic connected to weighted wire ropes—like a '70s bead curtain—so the bubbles won't break up, float away on currents, or entangle animals. In tests the curtain restored the natural commotion of the ocean, letting sea creatures natter on. *—Johnna Rizzo*



**GETTING AN EARFUL** Palm-size Philippine tarsiers have huge eyes but rely on their ears to stay sharp. The most acoustically acute primate, *Tarsius syrichta* hears sounds of up to 91 kilohertz (kHz)—a level inaudible to nearly all terrestrial mammals. Tuning in to high frequencies may help them snare insects and evade less perceptive predators. *—Lacey Gray*




PHOTOS: ERICH SCHLEGEL (TOP); AGRON DRAGAJ, FLICKR/GETTY IMAGES
GRAPHICS: KISS ME I'M POLISH (TOP); JASON TREAT, NGM STAFF
SOURCES: FEDERAL RESERVE (TOP); MARISSA A. RAMSIER, MARK E. COLEMAN

**MONTANA** *A deluge falls from the core of a thunderstorm near Glasgow in July 2010. "I felt like if you could stand in the middle and look up, you'd see straight into the heavens," says photographer Sean Heavey.*

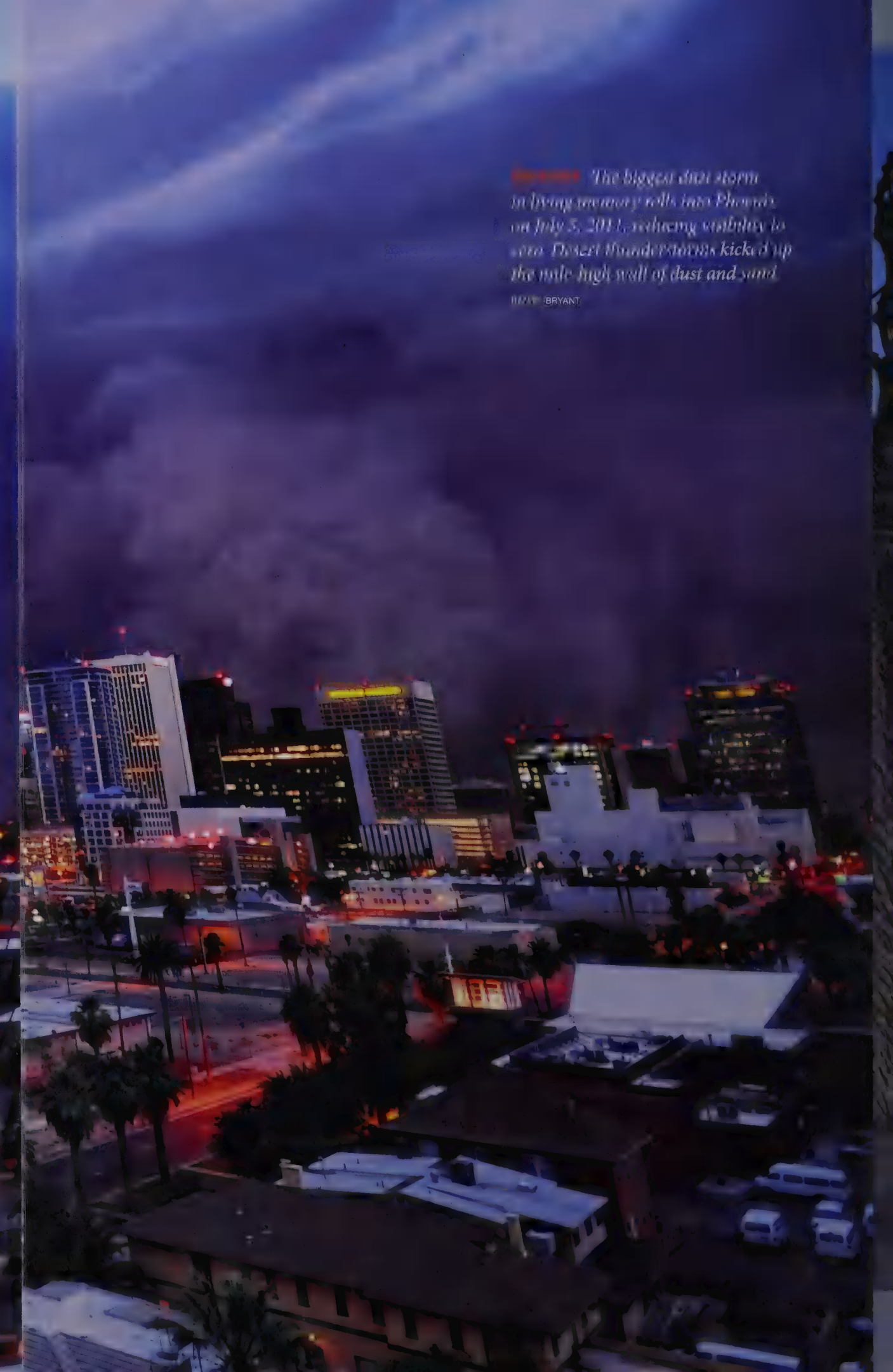
PANORAMA COMPOSED FROM IMAGES
SEAN R

# WEATHER GONE

# WILD

*Rains that are almost biblical, heat waves that don't end, tornadoes that strike in savage swarms—there's been a change in the weather lately. What's going on?*

BY PETER MILLER

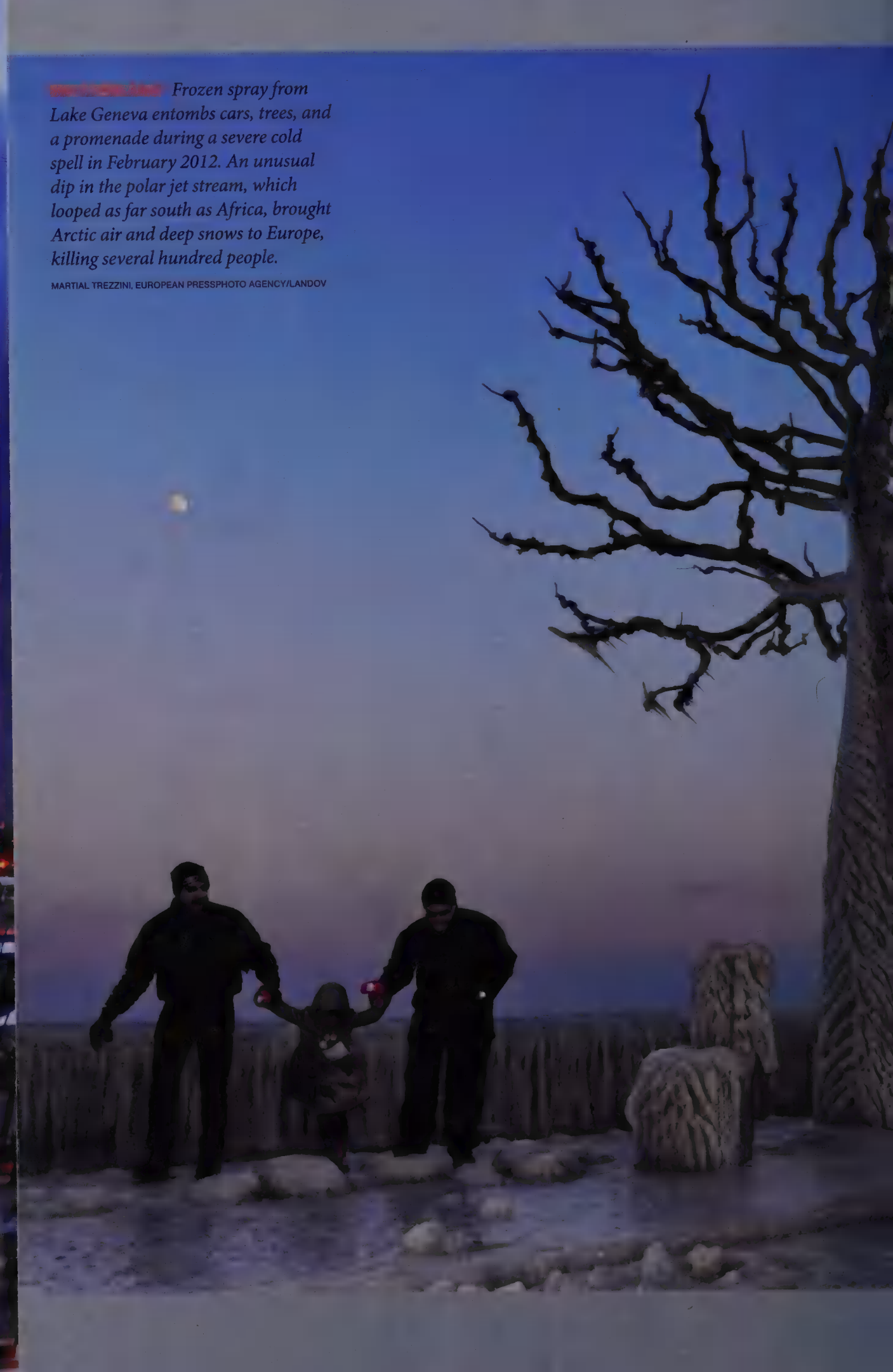


*The biggest dust storm in living memory rolls into Phoenix on July 5, 2011, reducing visibility to zero. Desert thunderstorms kicked up the mile-high wall of dust and sand.*

BRYANT

*A flaming fence post marks the trail of a forest fire near Bastrop on September 5, 2011, during a record drought and heat wave. The fire, which destroyed 1,685 houses, may have been sparked by dead pine trees falling onto power lines.*

LARRY W. SMITH, EUROPEAN PRESSPHOTO AGENCY/LANDOV



*Frozen spray from Lake Geneva entombs cars, trees, and a promenade during a severe cold spell in February 2012. An unusual dip in the polar jet stream, which looped as far south as Africa, brought Arctic air and deep snows to Europe, killing several hundred people.*

MARTIAL TREZZINI, EUROPEAN PRESSPHOTO AGENCY/LANDOV

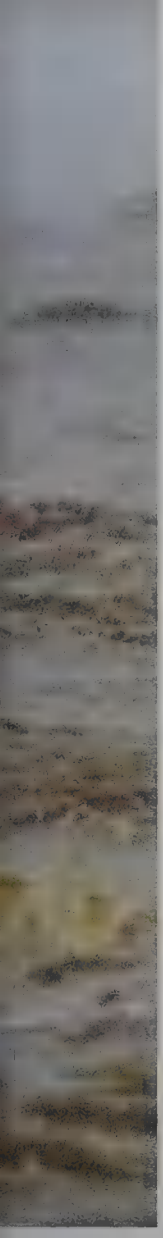
# THE WEEKEND FORECAST FOR NASHVILLE, TENNESSEE, CALLED FOR TWO TO FOUR INCHES OF RAIN.

But by the afternoon of Saturday, May 1, 2010, parts of the city had seen more than six inches, and the rain was still coming down in sheets.

Mayor Karl Dean was in the city's Emergency Communications Center monitoring the first reports of flash flooding when something on a TV screen caught his eye. It was a live shot of cars and trucks on Interstate 24 being swamped by a tributary of the Cumberland River southeast of the city. Floating past them in the slow lane was a 40-foot-long portable building from the Lighthouse Christian School.

"We've got a building running into cars," the TV anchorman was saying.

Dean had been in the "war room" for hours. But when he saw the



**TENNESSEE** *Jamey Howell and Andrea Silvia had just heard that church was canceled when the flood submerged their Jeep near Nashville on May 2, 2010. The teenagers clung to the roof rack for more than an hour and then—as their parents watched helplessly—let go. A mile downstream they struggled onto a riverbank, alive.*

RICK MURRAY

building floating down the highway, he says, "it became very clear to me what an extreme situation we had on our hands." Soon 911 calls were coming in from every part of the city. Police, fire, and rescue teams were dispatched in boats. One crew in a skiff headed out to I-24 to pluck the driver of an 18-wheeler from the chest-high water. Other teams pulled families off rooftops and workers from flooded warehouses. Still, 11 people died in the city that weekend.

This was a new kind of storm for Nashville. "It came down harder than I've ever seen it rain here," says Brad Paisley, the country singer, who owns a farm outside town. "You know how when you're in a mall and it's coming down in sheets, and you think, I'll give it five minutes, and when it lets up I'll run to my car? Well, imagine that it didn't let up until the next day."

Over at NewsChannel 5, the local CBS station, meteorologist Charlie Neese could see where the weather was coming from. The jet stream had gotten stuck over the city, and one thunderstorm after another was sucking up warm, humid air from the Gulf of Mexico, rumbling hundreds of miles northeast, and dumping the water on Nashville. While Neese and his colleagues were broadcasting from a second-floor studio, the first-floor newsroom was being swamped by backed-up sewers. "Water was shooting up through the toilets," Neese says.

The Cumberland River, which winds through the heart of Nashville, started rising Saturday morning. At Ingram Barge Company, David Edgin, a former towboat captain, had more than seven boats and 70 barges out on the waterway. As the rain continued to pound down, he called the U.S. Army Corps of Engineers to get its forecast of how high the river would rise. "It's blowing up our models," the duty officer said. "We've never seen anything like this." Edgin ordered all of Ingram's boats to tie up at safe locations along the riverbank. It turned out to be a smart move.

By Saturday night the Cumberland had risen at least 15 feet, to 35 feet, and the corps was predicting it would crest at 42. But the rain didn't stop Sunday, and the river didn't crest until Monday—at 52 feet, 12 feet above flood stage. Spilling into downtown streets, the flood caused some two billion dollars in damage.

When the sun came out on Monday morning, parts of Nashville had seen more than 13 inches of rain—about twice the previous record of 6.6 inches set during Hurricane Frederic in 1979. Pete Fisher, manager of the Grand Ole Opry, needed a canoe to get into the famous theater, which is on the riverfront northeast of the city. He and audio engineer Tommy Hensley paddled across a parking lot and through a side door. "We basically just floated into the theater," Fisher says. "It was pitch black, and we shined a light on the stage. If you'd been sitting in the front row, you'd have had seven feet of water over your head."

In warehouses along the river, the flood had submerged millions of dollars' worth of

equipment, including components for a 36-by-60-foot video screen that had been assembled for Brad Paisley's upcoming concert tour, which was set to begin in less than three weeks. "Every amp, every guitar I'm used to, was destroyed," Paisley says. "I felt powerless in a way I've never felt before with weather."

The experience changed him. "Here in Nashville our weather is manageable, normally," he says. "But since that flood, I've never once taken normalcy for granted."

**THERE'S BEEN A CHANGE** in the weather. Extreme events like the Nashville flood—described by officials as a once-in-a-millennium occurrence—are happening more frequently than they used to. A month before Nashville, torrential downpours dumped 11 inches of rain on Rio de Janeiro in 24 hours, triggering mud slides that buried hundreds. About three months after Nashville, record rains in Pakistan caused flooding that affected more than 20 million people. In late 2011 floods in Thailand submerged hundreds of factories near Bangkok, creating a worldwide shortage of computer hard drives.

And it's not just heavy rains that are making headlines. During the past decade we've also seen severe droughts in places like Texas, Australia, and Russia, as well as in East Africa, where tens of thousands have taken refuge in camps. Deadly heat waves have hit Europe, and record numbers of tornadoes have ripped across the United States. Losses from such events helped push the cost of weather disasters in 2011 to an estimated $150 billion worldwide, a roughly 25 percent jump from the previous year. In the U.S. last year a record 14 events caused a billion dollars or more of damage each, far exceeding the previous record of nine such disasters in 2008.

What's going on? Are these extreme events signals of a dangerous, human-made shift in Earth's climate? Or are we just going through a natural stretch of bad luck?

The short answer is: probably both. The primary forces driving recent disasters have been natural climate cycles, especially El Niño and La Niña. Scientists have learned a lot during the past few decades about how that strange seesaw in the equatorial Pacific affects weather worldwide. During an El Niño a giant pool of warm water that normally sits in the central Pacific surges east all the way to South America; during a La Niña it shrinks and retreats into the western Pacific. Heat and water vapor coming off the warm pool generate thunderstorms so powerful and towering that their influence extends out of the tropics to the jet streams that blow across the middle latitudes. As the warm pool shifts back and forth along the Equator, the wavy paths of the jet streams shift north and south—which changes the tracks that storms follow across the continents. An El Niño tends to push drenching storms over the southern U.S. and Peru while visiting drought and fire on Australia. In a La Niña the rains flood Australia and fail in the American Southwest and Texas—and in even more distant places like East Africa.

**ARE WE SEEING A DANGEROUS SHIFT IN CLIMATE? OR JUST A NATURAL STRETCH OF BAD LUCK?**

Those outcomes aren't mechanical and invariable; the atmosphere and ocean are chaotic fluids, and other oscillations influence the weather at a given time and place. The tropical Pacific is especially influential, though, because it pumps so much heat and water vapor into the atmosphere. Extreme El Niños or La Niñas thus set the stage for extreme events elsewhere.

But natural cycles can't by themselves explain the recent streak of record-breaking disasters.

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*Senior Editor Peter Miller wrote the January cover story on the scientific study of twins.*

Something else is happening too: The Earth is steadily getting warmer, with significantly more moisture in the atmosphere. Decades of observations from the summit of Mauna Loa in Hawaii, as well as from thousands of other weather stations, satellites, ships, buoys, deep-ocean probes, and balloons, show that a long-term buildup of greenhouse gases in the atmosphere is trapping heat and warming up the land, oceans, and atmosphere. Although some places, notably the Arctic, are warming faster than others, the average surface temperature worldwide has risen nearly one degree Fahrenheit in the past four decades. In 2010 it reached 58.12°F, tying the record set in 2005.

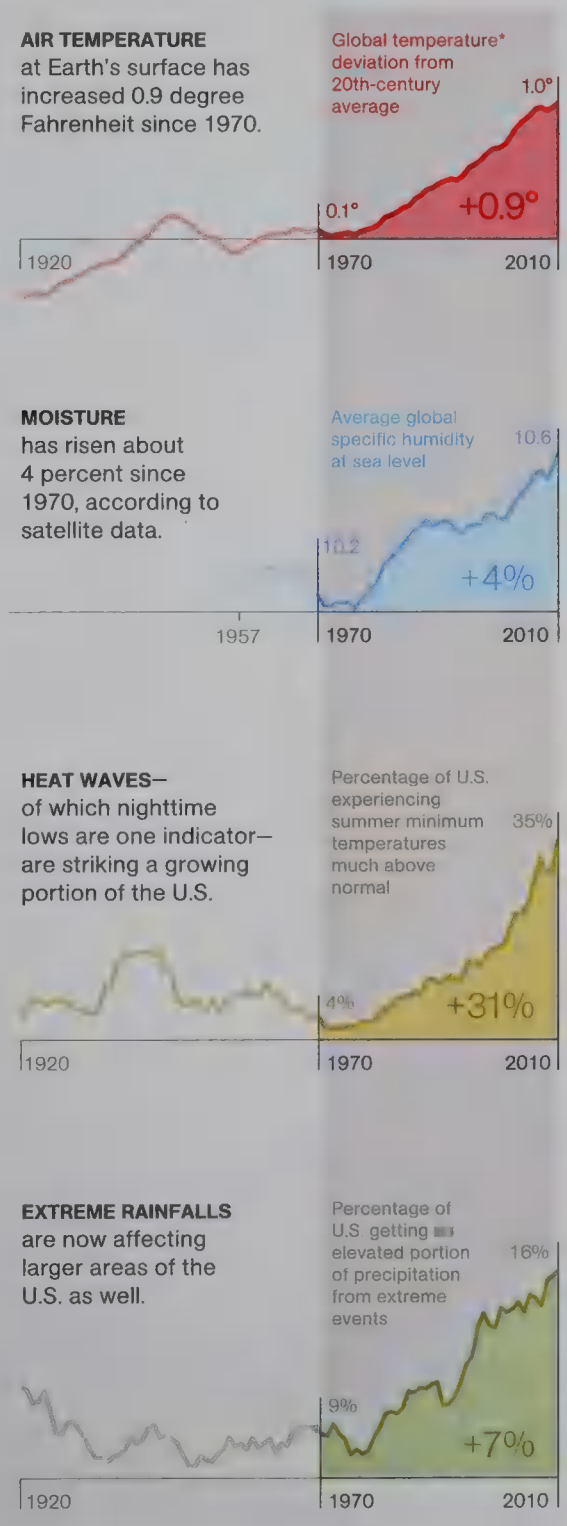
As the oceans warm, they're giving off more water vapor. "Everybody knows that if you turn up the fire on your stove, you evaporate the water in a pot more rapidly," says Jay Gulledge, senior scientist at the Center for Climate and Energy Solutions (C2ES), a think tank in Arlington, Virginia. During the past 25 years satellites have measured a 4 percent average rise in water vapor in the air column. The more water vapor, the greater the potential for intense rainfalls.

By the end of the century the average world temperature could rise anywhere from three to eight degrees Fahrenheit—depending in part on how much carbon we emit between now and then. Scientists expect the weather to change substantially. Basic circulation patterns will move toward the Poles, just as some plants and animals are doing as they flee (or take advantage of) the expanding heat. The tropical rain belt is already widening, climatologists report. The subtropical dry zones are being pushed poleward, into regions such as the American Southwest, southern Australia, and southern Europe, making these regions increasingly susceptible to prolonged and intense droughts. Beyond the subtropics, in the midlatitudes, including the lower 48 of the United States, storm tracks are moving poleward too—a long-term trend superimposed on the year-to-year fluctuations triggered by La Niña or El Niño.

One of the biggest wild cards in our weather future is the Arctic Ocean, which has lost 40

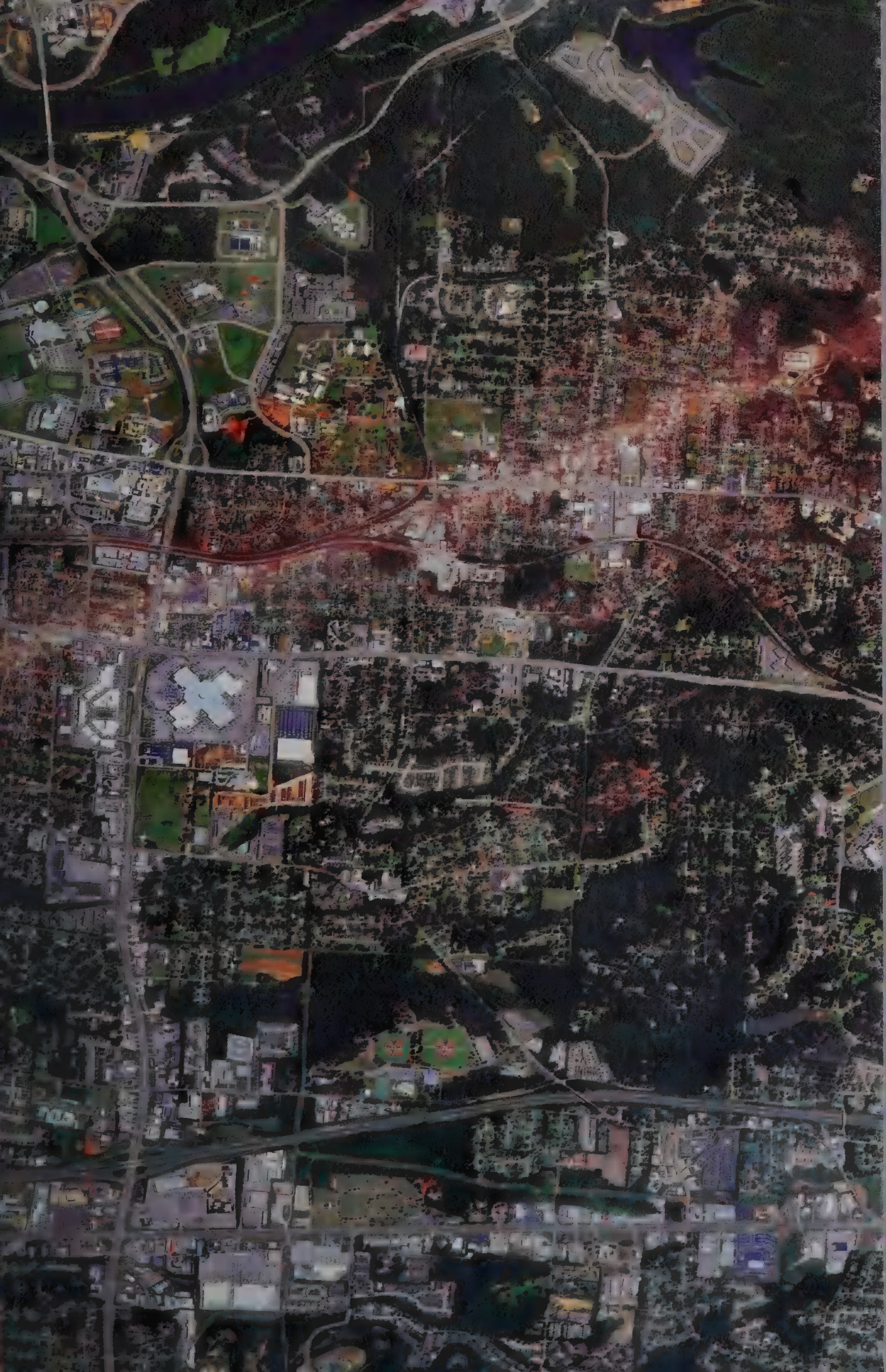
# WHY SO WILD?

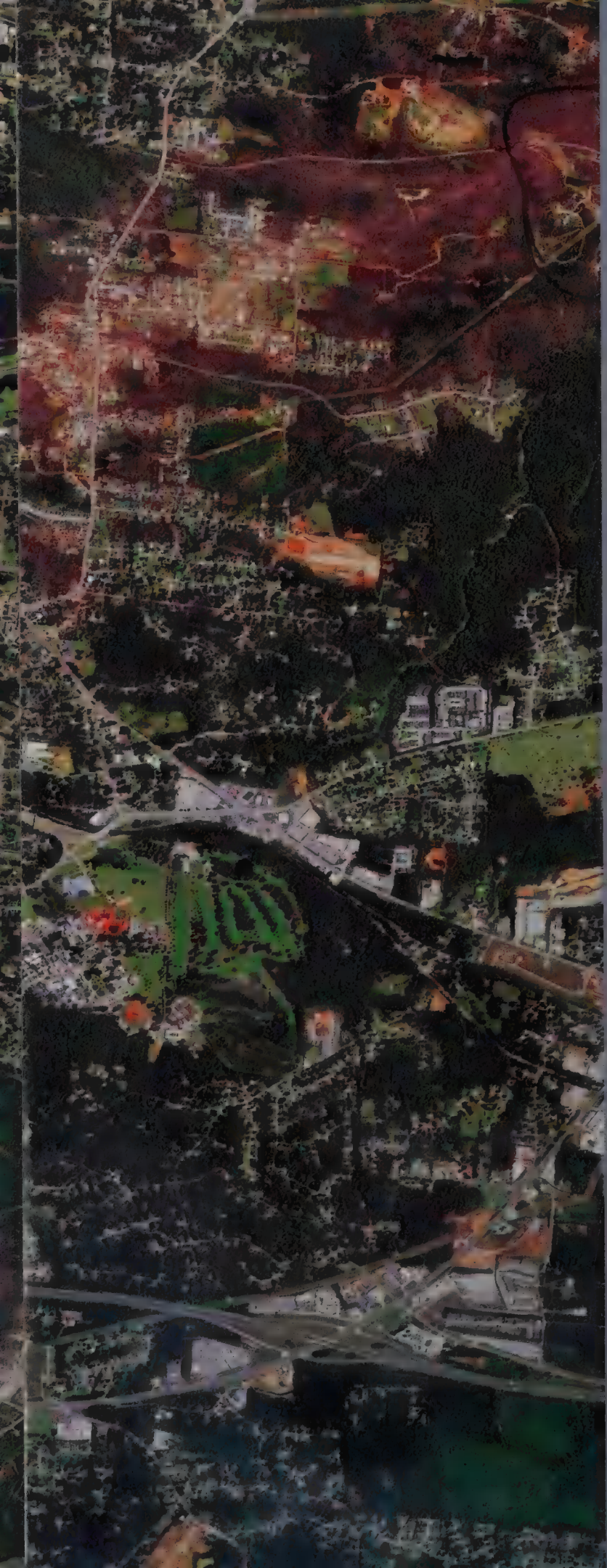
The atmosphere is getting warmer and wetter. Those two trends, which are clear in data averaged globally and annually, are increasing the chances of heat waves, heavy rains, and perhaps other extreme weather.




GRAPHS ABOVE ARE SMOOTHED USING A TEN-YEAR MOVING AVERAGE.
*AVERAGE TEMPERATURE OVER LAND AND OCEAN

JOHN TOMANIO, NGM STAFF; ROBERT THOMASON
SOURCES: JEFF MASTERS, WEATHER UNDERGROUND; NATIONAL CLIMATIC DATA CENTER (TEMPERATURE, HEAT WAVES, AND RAINFALL); NOAA (HUMIDITY)





**ALABAMA** *On April 27, 2011, the U.S. was hit by 199 tornadoes, a single-day record—but there's no clear evidence, scientists say, of a long-term rise in tornado frequency. The 190-mile-an-hour twister that carved a sharp path across Tuscaloosa missed the University of Alabama football stadium (upper left) by a mile, then threaded between a large mall (X-shaped building at center) and the main hospital, which was soon treating victims. The tornado killed 44, then roared northeast to the Birmingham area, where it killed 20 more.*

DIGITALGLOBE

NEBRASKA

## *"It was really cranking."*

*At 130 miles an hour, to be precise—but to photographer Mike Hollingshead, that was not a clue to run the other way. A dedicated storm chaser, Hollingshead caught this funnel on June 20, 2011, outside Bradshaw, near I-80, where it derailed several freight-train cars. A TV crew (far right) also raced in for a closer look.*

MIKE HOLLINGSHEAD (ALL)

percent of its summer sea ice since the 1980s. Autumn temperatures over what is now open ocean have risen 3.6 to 9°F, as the dark water absorbs sunlight that the ice once bounced back into space. New evidence suggests that warming is altering the polar jet stream, adding lazy north-south meanders to its path around the planet—which might help to explain why North America was so warm last winter and Europe so cold. Meandering farther north than normal into Canada, the jet stream brought warm air with it; dipping far south over Europe, it delivered frigid winds and snow to that region. In the winter of 2010-11 it was eastern North America that got heavy snow. Because the meanders move around every year, the extreme weather may too.

When it comes to individual storms, scientists are even less certain what effect global warming might have. In theory extra water vapor in the atmosphere should pump heat into big storms such as hurricanes and typhoons, adding buoyancy that causes them to grow in size and power. Some models have predicted that global warming could increase the average strength of hurricanes and typhoons by 2 to 11 percent by 2100. But the jury's still out on whether any increase has occurred yet. And the same models that predict bigger hurricanes also say we could get fewer of them in the future.

The picture is murkiest with tornadoes. A hotter, wetter atmosphere should promote more severe thunderstorms, but it might also reduce the wind shear needed for those storms to spawn twisters. More tornadoes are being reported in the U.S., but there are more people looking for them with better instruments—and there's been no documented increase in the past half century in the number of severe tornadoes. The spring of 2011 was one of the worst tornado seasons in U.S. history, with monster twisters roaring through Tuscaloosa, Alabama, and Joplin, Missouri. But scientists don't yet have the data or the theoretical understanding to say whether global warming was to blame.

In the case of some weather extremes, though, the connection is pretty clear. The warmer the atmosphere, the more potential for record-breaking heat waves. In the U.S. high-temperature records are being set these days twice as often as low-temperature ones; around the world 19 countries set national records in 2010.

As moisture in the atmosphere has increased, rainfall has intensified. The amount of rain falling in intense downpours—the heaviest one percent of rain events—has increased by nearly 20 percent during the past century in the U.S. "You're getting more rain from a given storm now than you would have 30 or 40 years ago," says Gerald Meehl, a senior scientist at the National Center for Atmospheric Research in Boulder, Colorado. Global warming, he says, has changed the odds for extreme weather.

THE AMOUNT OF RAIN FALLING IN THE HEAVIEST DOWNPOURS HAS INCREASED NEARLY 20 PERCENT.

"Picture a baseball player on steroids," Meehl goes on. "This baseball player steps up to the plate and hits a home run. It's impossible to say if he hit that home run because of the steroids, or whether he would have hit it anyway. The drugs just made it more likely."

It's the same with the weather, Meehl says. Greenhouse gases are the steroids of the climate system. "By adding just a little bit more carbon dioxide to the climate, it makes things a little bit warmer and shifts the odds toward these more extreme events," he says. "What was once a rare event will become less rare."

**NOBODY HAS LIVED THROUGH** more weather on steroids lately than Texans. The 1,049 residents of Robert Lee, a West Texas town of ranchers,

oil workers, retirees, and small business owners, spent much of 2011 watching their water supply dry up. The E. V. Spence Reservoir, like many lakes in the region, lost more than 99 percent of its water.

"If we don't get some additional runoff soon, there will be no more water coming out of the faucets," Mayor John Jacobs said last winter. "As in nothing. It's getting serious." In January the town began construction of a 12-mile pipeline to Bronte, a community that has wells in addition to a reservoir. Completed in March, the pipeline was still being tested in early May. "We feel like we're going to get it done in time," Jacobs said. "But it's going to be just under the wire. Living in West Texas is not for the weak at heart."

Less rain fell on Texas from October 2010 to September 2011 than in any other 12-month period since record keeping began in 1895. The whole state suffered, but West Texas was already close to the edge. All across the region farmers, ranchers, and municipalities were feeling the damage. (See "The New Dust Bowl," page 56.) In many places water levels dropped below well pumps, causing the motors to burn out. "A lot of wells are going dry," said Clark Abel, a well driller in San Angelo. "Our phone's been ringing off the hook. It's overwhelming."

The drought withered grazing lands too, forcing some ranches to ship their livestock to greener pastures up north. In a kind of modern cattle drive, ranch hands from the Four Sixes Ranch near Guthrie and from its Dixon Creek operation in the Texas Panhandle drove more than 4,000 head of Angus crossbreeds onto double-decker trucks to transport them to leased lands from Nebraska to northern Montana.

The last time the Four Sixes attempted such a thing, said general manager Joe Leathers, was more than a century ago, when the ranch moved herds to what was then the Indian Territory of Oklahoma. This drought was worse. By last July the ranch had run out of tank water—drinking water in dirt ponds for cattle. "The long and the short of it is that nobody has ever faced anything like this before," Leathers said.

"This has been the most severe one-year drought we've ever had," said state climatologist John Nielsen-Gammon. (A drought in the 1950s took six years to get as bad.) On top of that, Texans sweated last year through the hottest summer in memory. Dallas residents saw the mercury climb to 100°F or higher on 71 days.

There's no mystery about the main cause, Nielsen-Gammon said: It was La Niña, which pushed storm tracks farther north over the U.S., reducing rainfall throughout the South, from Arizona to the Carolinas. "We just happened to be right in the center of it," he said.

But global warming aggravated the situation, making an already bad heat wave even worse. "Under normal conditions a lot of the sun's energy gets used to evaporate water from the soil or from plants," Nielsen-Gammon explained. "But when there's no water to evaporate, all that energy goes into heating the ground and consequently heating the air. Given how little rain we had, we probably would have had record warmth in Texas in 2011 even without climate change. But climate change added an additional degree or so of heat to it."

That extra degree of heat was like an extra shot of gasoline on the state's forests: By increasing evaporation, it made them even drier. In a drought, said Nielsen-Gammon, "every little increase in severity makes a big difference." Texas in 2011 experienced the worst wildfire season on record. Taken together, the fires blackened an area larger than Connecticut—nearly twice as much acreage as in the previous worst year.

One of the costliest fires started last September just outside Bastrop State Park, southeast of Austin, where the loblolly pines were as dry and brittle as kindling. Fanned by strong winds, the blaze raced south through suburban neighborhoods in what firefighters call long "streets" of fire. It consumed 1,685 houses but occasionally spared others nearby, leaving residents shaking their heads.

When Paige and Ray Shelton returned to inspect their property adjacent to the state forest, they found their bungalow still standing, but the sawmill that Ray operated with his brother, Bo, was reduced to ashes and Paige's pottery studio

**CHINA** *Rainwater cascades onto a Chengdu resident rushing up a flight of stairs from an underground garage. An unusually severe downpour on July 5, 2015, flooded streets and knocked out electricity in the city, which is the capital of Sichuan Province in central China.*

CHINA DAILY/REUTERS

was burned to the ground. As Paige picked through the wreckage, Ray made a beeline for the chicken coop, hoping to spare his wife the sorrow of cleaning up all the burned carcasses. Trees all around the coop were charred black.

"Well, guess what?" Ray said later. "As I came around the corner, the rooster stuck his head out and crowed. I couldn't believe it. I almost fell over backwards."

The fire had come within an inch of the coop, but for some reason the red cedar walls hadn't ignited, and somehow the birds had avoided the intense heat and smoke—a small miracle in the midst of great loss. All five hens had survived too, along with 18 doves Paige was raising. "They were singing up a storm," Ray said.

**MISSISSIPPI** *Fortified by a levee, a house near Vicksburg survives a Yazoo River flood in May 2011. Snowmelt and intense rains—eight times as much rainfall as usual in parts of the Mississippi River watershed—triggered floods that caused three to four billion dollars in damages.*

SCOTT OLSON, GETTY IMAGES

THE RISING COST and frequency of natural disasters can be blamed only partly on the weather. Disasters are also on the rise because more people are located in harm's way. In states like Texas, Arizona, and California the buildup of neighborhoods in former woodlands has exposed more properties to wildfires, just as coastal development in states like Florida, North Carolina, and Maryland has exposed expensive beach houses and hotels to hurricanes and other storms. At the same time, the rapid growth of megacities in developing countries in Asia and Africa has made millions more vulnerable to heat waves and floods. Instead of defending themselves against climate change, many communities appear to be leading with their chin.

"Something has gone wrong," says climatologist Michael Oppenheimer of Princeton University, who helped write a recent report on extreme weather for the Intergovernmental Panel on Climate Change. "To put it bluntly, we're doing a lousy job keeping up with disasters."

The economic significance of this hasn't been lost on the insurance industry. Insured losses from natural disasters in the U.S. last year totaled nearly $36 billion, 50 percent higher than the average during the previous decade. "Whether it's the 'new normal' or not, the industry sees a pattern of losses that's extraordinary," says Frank Nutter of the Reinsurance Association of America. "The past is not prologue to the type of weather we're about to see."

In Florida, where hurricanes, wildfires, and drought pose enormous risks to insurers, several national firms have stopped writing new policies altogether or pulled back in other ways. They're afraid of another disaster like Hurricane Andrew in 1992, which cost the industry an estimated $25 billion. To fill the gap, small companies have sprung up across the state, and in 2002 the state government created the Citizens Property Insurance Corporation, which has become Florida's largest provider of homeowner's insurance. Whether this new system has the resources to survive a big storm isn't clear yet, Nutter says. "It's an untested experiment. They haven't had a major hurricane there since 2005."

Meanwhile some governments have taken small but important steps to better prepare for

extreme weather. An exceptional heat wave in Europe in 2003 took at least 35,000 lives; a later analysis found that climate change had doubled the odds of such a disaster. Afterward French cities set up air-conditioned shelters and identified older people who would need transportation to the shelters. When another heat wave hit France in 2006, the death rate was two-thirds lower.

Similarly, after a tropical storm killed as many as 500,000 people in Bangladesh in 1970, the government there developed an early warning system and built basic concrete shelters for evacuated families. When cyclones hit today, the death count stays in the thousands.

Weather disasters are like heart attacks, says Jay Gulledge. "When your doctor advises you about how to avoid a heart attack, he doesn't say, Well, you need to exercise, but it's OK to keep smoking," he says. The smart approach to extreme weather is to attack all the risk factors, by designing crops that can survive drought, buildings that can resist floods and high winds, policies that discourage people from building in dangerous places—and of course, by cutting greenhouse gas emissions.

"We know that warming of the Earth's surface is putting more moisture in the atmosphere. We've measured it. The satellites see it," Gulledge says. So the chances for extreme weather are going nowhere but up.

We need to face that reality, Oppenheimer says, and do the things we know can save lives and money. "We don't have to just stand there and take it." □

**Educational Note** National Geographic has free educational resources about weather for students, teachers, and families at *natgeoed.org/weather*.

# BILLION-DOLLAR WEATHER

A chart of the most costly U.S. weather disasters shows nearly twice as many billion-dollar events since 1996 as in 1980-1995. The main reason: More people are living on higher-value properties in vulnerable places, such as coasts. But as the atmosphere warms, scientists expect destructive weather itself to become more common.

## 46 DISASTERS

Causing at least $1 billion in damages, 1980-1995

**Total losses: $339 billion**

*ALL DOLLAR AMOUNTS ADJUSTED TO MARCH 2012 DOLLARS

JOHN TOMANIO, NGM STAFF. SOURCES: ADAM SMITH, NATIONAL CLIMATIC DATA CENTER; JEFF MASTERS, WEATHER UNDERGROUND; NATIONAL CLIMATIC DATA CENTER

**ALL U.S. WEATHER DISASTERS** from 1980 to 2011 that caused at least one billion dollars* in damages are plotted by month and year; the size of each half circle represents the cost of the disaster. The ten most costly events are labeled.

**COST OF DISASTER**

$50 BILLION

$20

$10

**DISASTER TYPE**

- Drought/heat wave
- Wildfire
- Flood
- Hurricane
- Tornado/hailstorm/thunderstorm
- Blizzard/ice storm/freeze

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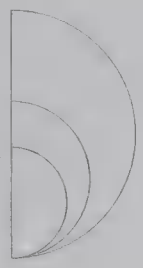


**DISASTER TYPE**

- Drought/heat wave
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# 87 DISASTERS

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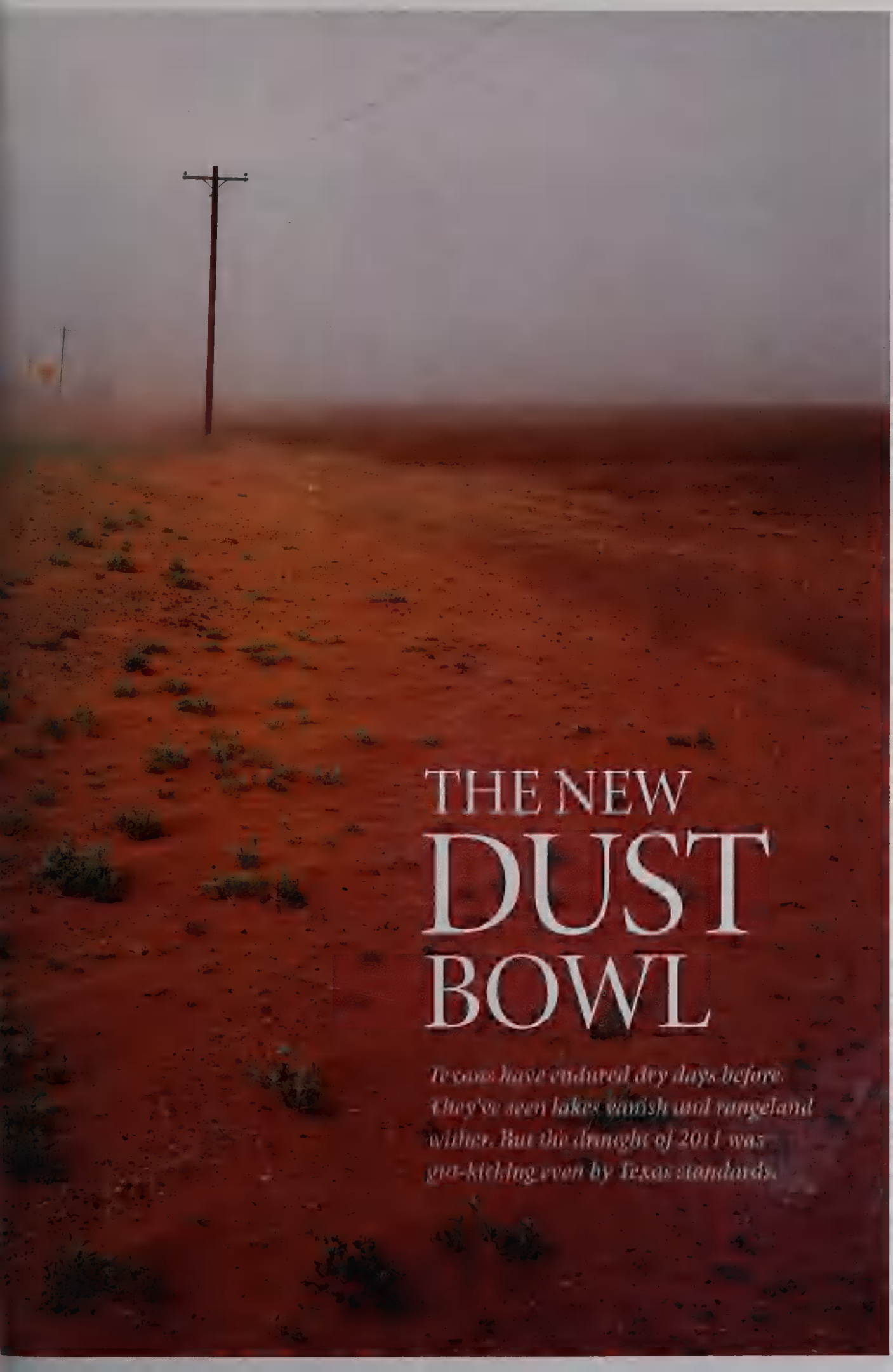
**PEP** *Gusting winds fling dirt from barren cotton fields onto Farm to Market Road 303, near a small community called Pep. Parts of West Texas saw next to no rainfall in 2011.*



# THE NEW DUST BOWL

*Texans have endured dry days before. They've seen lakes vanish and rangeland wither. But the drought of 2011 was gut-kicking even by Texas standards.*

PHOTOGRAPHS BY ROBB KENDRICK

# HE'S SEEN IT ALL BEFORE. BACK IN THE DUST BOWL DAYS HE WATCHED IN AWE AS DARK CLOUDS OF TOPSOIL SWALLOWED UP THE FAMILY RANCH.

That was in the mid-1930s, when Bill Tullos was just a boy. He still lives on the ranch outside San Angelo, Texas, and that memory is still vivid. "Day turned to night," he recalls.

It was even worse in the 1950s. The rains didn't come. Grazing lands withered. Water holes dried up. "We said, Well, it will rain tomorrow," Tullos says. "We waited seven years before it finally broke."

Last year he saw the signs once more. "Normally May and June are our rainy months, and we just weren't getting any rain," he says. So he started selling his animals at the local auction house. First the cattle, then the sheep and goats. "The 1950s nearly broke me. This time I was determined it wasn't going to happen to me."

By the end of 2011 Tullos was down to 300 goats on his 8,000-acre spread. The man who had seen it all—taking over the family business at 16 after his father died—was calling it quits. "It was nearly heartbreaking, it sure was," he says.

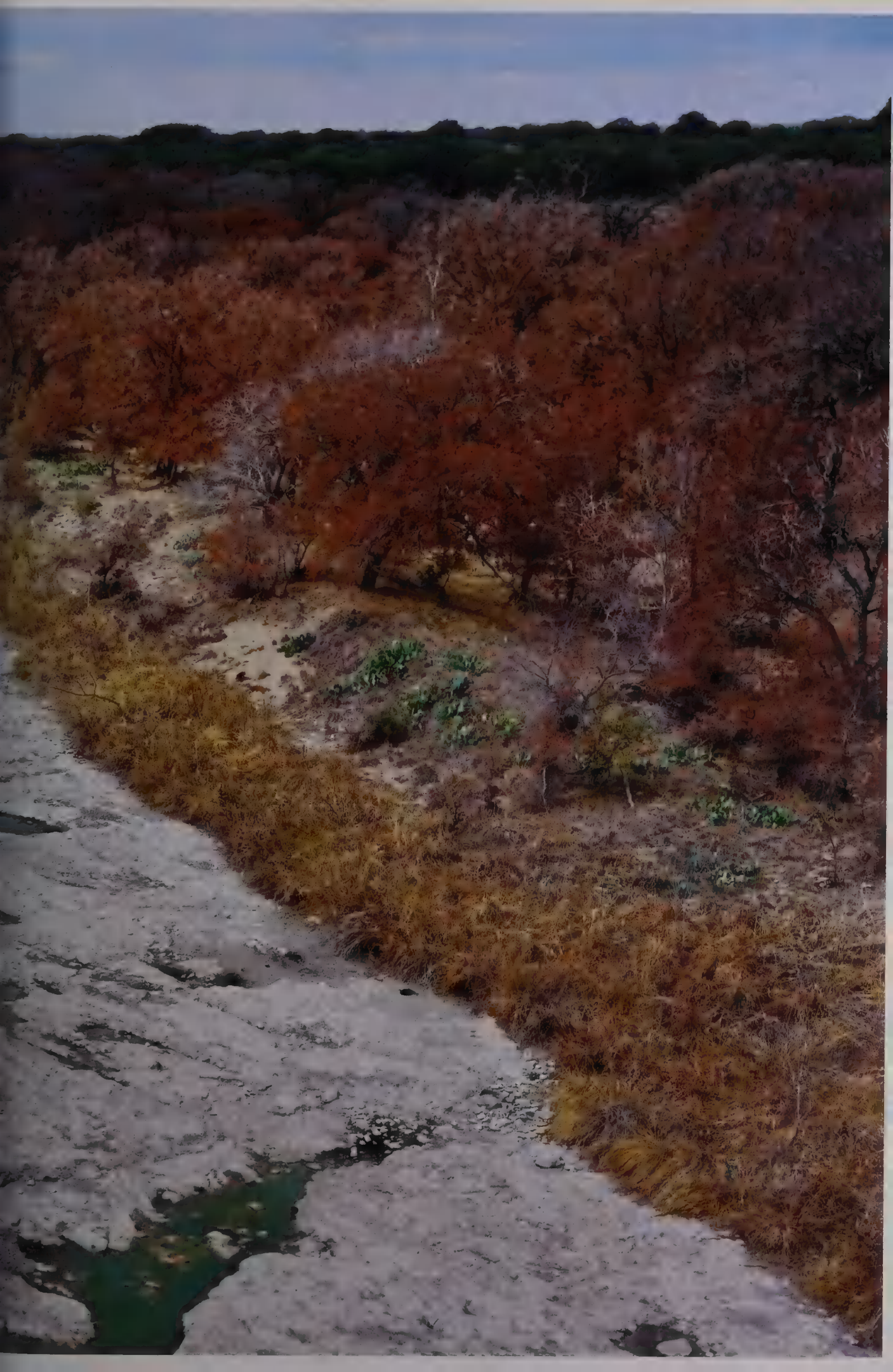
All across West Texas, men and women accustomed to toughing it out were nearing their breaking point. Those who managed to hang on were spending a fortune on feed and hay for livestock or on water to irrigate dusty fields. The air was so hot and dry, much of the water sprayed on the soil evaporated before it could soak in. "They just couldn't keep up," Buzz Cooper says of the cotton farmers near Lubbock who normally bring their crops to his gin. In May two-thirds of the nearby fields were bare ground.

By September Texas had suffered the driest 12 months in its history. Farmers across the state lost more than eight billion dollars. In West Texas, where people are used to hardship, the drought caused some to question whether their way of life was even possible anymore. Although the winter at last brought some nourishing rain, they still faced a long road back to good times. *—Peter Miller*

Download our iPad edition to watch a video about the dust-choked fields of West Texas—and the farmers who won't give up.

**SAN ANGELO** *"If you're proud of your country, you try to take care of it," says Bill Tullos. Last year, rather than watch his animals graze drought-stricken pastures to bare dirt, he sold most of them to protect the land.*

**TEXAS HILL COUNTRY** *In better days the San Saba River between Menard and Brady is a 50-foot-wide stream filled with largemouth bass and bald cypress. Last year it dried up completely. These trees aren't autumnal; they're dying.*



**VERIBEST** *In this very small town, the Friday night game at Veribest High is a major event. "Football's huge," says Falcons head coach Grant Richmond (at far right). Despite the drought and record-breaking heat, the school managed to water its field enough to keep most of the grass green. Practices were brutal, though, Richmond says. "I tried not to look at a thermometer."*

**MASON** *As the drought dried up grazing lands, ranchers converged on the Mason Feed Store. "They bought a lot of hay and feed to save at least their younger cows," says Kenneth Durst, who's worked here for 48 years. Later, after ranchers reduced their herds, sales dropped off. But demand for wildlife feed remained steady, as landowners and hunters tried to sustain deer, quail, and turkeys.*

**SAN ANGELO** *Well drillers Clark Abel (top) and his son, Justin, install the head of a windmill that will pump water from a new and deeper well. Drought is good for their business—but in the long run would drive people away from West Texas.*

# Mountains in the Sea

*Hundreds of thousands of seamounts rise from Earth's ocean floor. Life has been explored on barely 300.*

*The submersible DeepSee, some 600 feet below the surface of the Pacific, descends into a volcanic vent of the seamount Las Gemelas.*

*A harbor seal peers from a kelp forest on Coronado, a series of rocky islands and pinnacles off the coast of San Diego. This shallow, light-filled habitat supports a wide variety of animals and plants.*

BY GREGORY S. STONE
PHOTOGRAPHS BY BRIAN SKERRY

**Sealed in our submersible, *DeepSee*, we wait, watching the crew on *Argo*'s deck shout orders to each other—a movie without a sound track.**

Then we are untied, drifting, a tiny dot on the immense Pacific Ocean. Pilot Avi Klapfer floods the ballast tanks, and we sink, surrounded by bubbles. It's like falling into a glass of champagne, and we feel appropriately giddy. A diver pokes through the bubbles to make a final adjustment to the camera housing mounted on the outside of the sub. Out there with the camera are hydraulics, thrusters, and hundreds of other essential parts that will keep us safe.

Three of us—Klapfer, photographer Brian Skerry, and I—are crammed inside *DeepSee*'s five-foot sphere, surrounded by communication equipment, pressure valves, controls, snacks, cameras, special bags to urinate in: everything we need for our quest to reach a seamount named Las Gemelas. Its cluster of peaks, rarely seen up close before, rises from the bottom of the Pacific near Cocos Island, 300 miles southwest of Cabo Blanco in Costa Rica. The highest peak here is more than 7,500 feet tall.

Seamounts generally form when volcanic mountains rise up from the seafloor but fail to reach the surface (those that break the surface become islands). Scientists estimate that there

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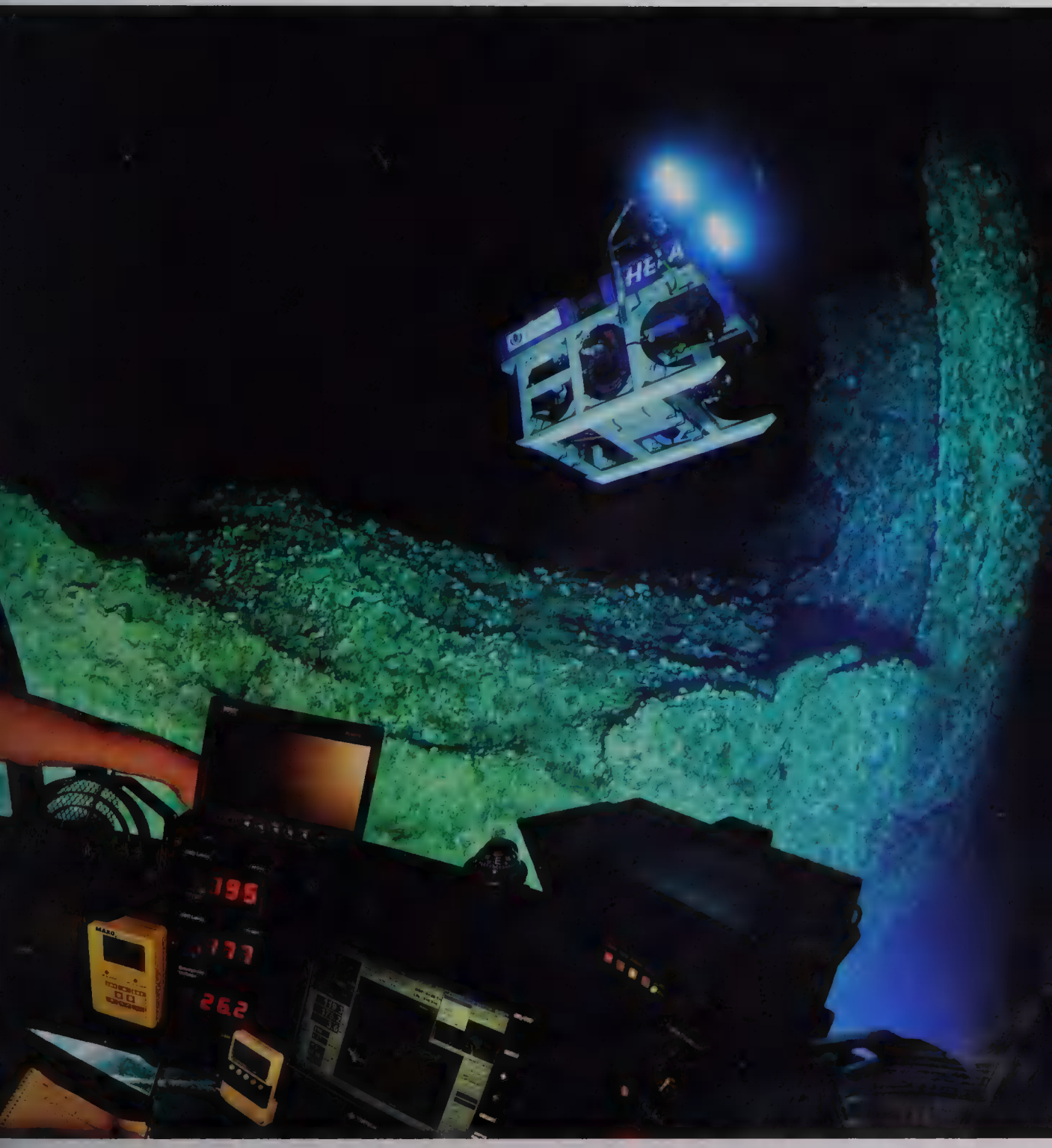
*Gregory S. Stone is a senior vice president and chief ocean scientist at Conservation International. Brian Skerry's book* Ocean Soul *was published in 2011.*



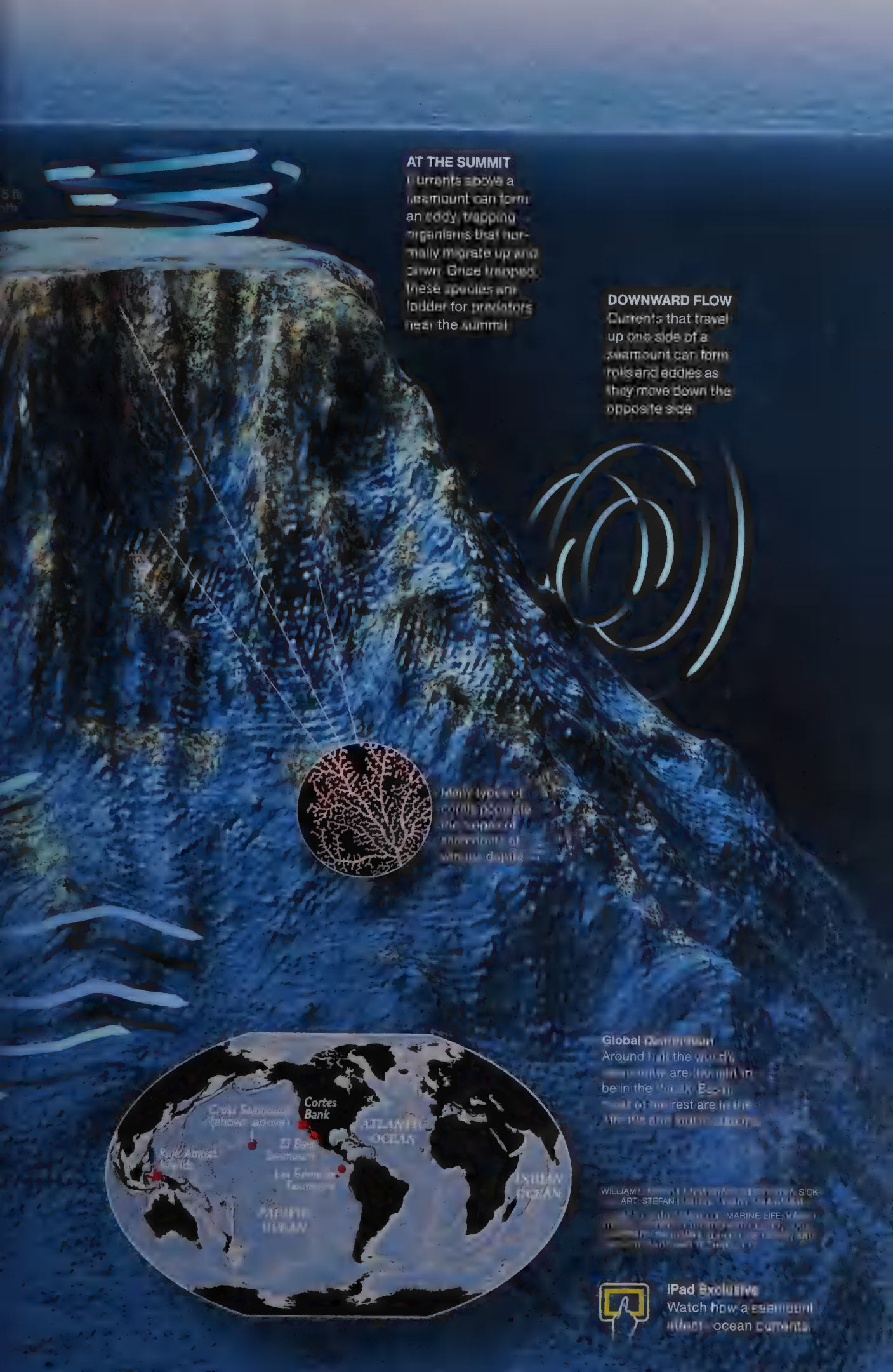

*Author Greg Stone, aboard the submersible* DeepSee, *watches a remotely operated vehicle maneuver around Las Gemelas. Braving strong currents, rough terrain, and technical glitches, a ten-person team spent seven days studying the seamount in early 2012.*

THIS ARTICLE WAS FUNDED IN PART BY THE NATIONAL SCIENCE FOUNDATION UNDER GRANT NO. DRL-1114251. ANY OPINIONS, FINDINGS, AND CONCLUSIONS OR RECOMMENDATIONS ARE THOSE OF THE AUTHOR AND DO NOT NECESSARILY REFLECT THE VIEWS OF THE NATIONAL SCIENCE FOUNDATION.

Undersea mountains take many forms—from this flat-topped guyot to smaller pinnacles to vast rolling hills with bases spanning 60 miles or more. Surfaces may be scarred with craters, crevices, and ridges
10,000 ft
UPWARD FLOW
Currents collide with the base and accelerate upward, carrying cold, nutrient-rich water toward areas near the surface and providing food for animals living in the vicinity
OCEAN CURRENTS

# Tour of a Seamount

Undersea mountains, mainly volcanic in origin, rise in the hundreds of thousands from the ocean floor. One of Earth's most prominent physical features, they compare in size with terrestrial mountains but are likely more numerous.


AT THE SUMMIT
Currents above a seamount can form an eddy, trapping organisms that normally migrate up and down. Once trapped, these species are fodder for predators near the summit
DOWNWARD FLOW
Currents that travel up one side of a seamount can form rolls and eddies as they move down the opposite side
Cortes Bank
ATLANTIC OCEAN
INDIAN OCEAN
PACIFIC OCEAN
Global Connection
Around half the world's
be in the
rest are in the
WILLIAM
ART STEFAN
MARINE LIFE
SICK
iPad Exclusive
Watch how a seamount
ocean currents

GASTROPOD MOLLUSK (*FIUSITRON MAGELLANICUS*)

DECAPOD (*EICONAXIUS* SP.)

SEA URCHIN (*DERMECHINUS HORRIDUS*)

BRITTLE STAR

CORAL (*IRIDOGORGIA* SP.)

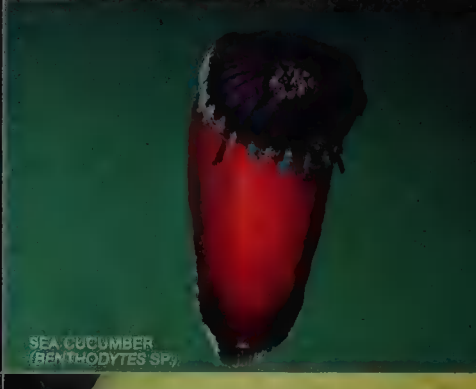
FEATHERY BLACK CORAL (ANTIPATHERIA)

# Life on a Mount

*Oases of abundance, seamounts attract, harbor, and sustain diverse communities of animals. These images represent a minuscule sampling of the sponges, corals, crustaceans, gastropods, vertebrates, and other creatures that live on or around undersea peaks, rich with waterborne nutrients. Scientists still have much classifying and cataloging to do: New species are discovered on almost every expedition.*

BUBBLEGUM CORAL (PARAGORGIIDAE)

SPONGE (*FARREA* SP.)



SEA CUCUMBER (*BENTHODYTES* SP.)

VENUS FLYTRAP ANEMONE

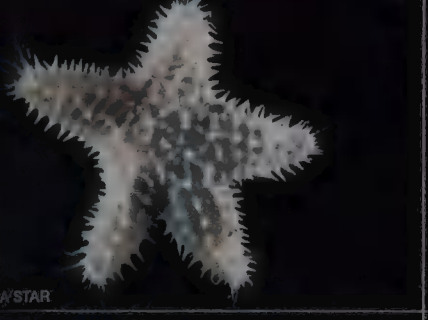
BOTTLEBRUSH CORAL (*KEROEIDES*)

DEEPWATER BIGEYE SHRIMP (*PANDALOPSIS AMPLA*)

BATFISH (OGCOCEPHALIDAE)

SEA

SQUAT LOBSTER (*MUNIDA*)



A STAR

GASTROPOD MOLLUSK (CALLIOSTOMATIDAE)

PENCIL [illegible] WITH HYDROIDS

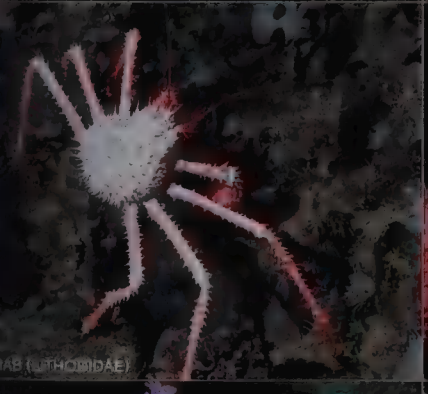
RAL (*ENALLOPSAMMIA* SP.)

HYDROID

SEA SQUIRT (TUNICATA)

BBLEGUM

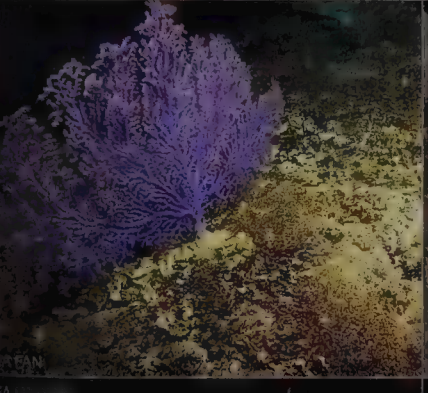
CORAL (*IRIDOGORGIA* SP.)



AB (LITHODIDAE)

PICASSO SPONGE

GASTROPOD MOLLUSK (NUDIBRANCHIA)



FAN

GAPER (CHAUNACIDAE)

OLYECHINUS GULHENSIS)

SEA FAN

NATURE PICTURE LIBRARY [5]. ROW 4: [illegible] NATURE PICTURE LIBRARY [5]. ROW 5: NOAA/MBARI (1); NOAA [illegible] [3]; WAITT [illegible] NATIONAL INSTITUTE [illegible] WATER & ATMOSPHERIC RESEARCH, NEW ZEALAND [5]. ROW 6: [illegible] NATURE [illegible] [ALL]

are some 100,000 seamounts at least one kilometer (3,281 feet) high. But if you include others that range from small hills to rolling mountains, there may be as many as a million of them.

We've seen little of these oases of life in the deep. Of all Earth's seamounts, marine biologists have studied only a few hundred. More finely detailed maps of the surface of Mars may exist than of the remotest parts of the ocean floor.

Scientists don't often explore their slopes firsthand—or even their shallower summits: living mazes of hard coral, sponges, and sea fans circled by schools of fish, some of them orange roughy that have lived to be more than a hundred years old. Among the teeming life, might there be new species that could produce new chemical compounds that can cure diseases, possibly even cancer?

Las Gemelas was designated a Seamounts Marine Management Area in 2011 by Laura Chinchilla, president of Costa Rica. Her goal: to "help set clear parameters to defend one of the greatest zones of marine wealth on the planet." But for seamounts worldwide, this wealth is threatened. More and more, deep-sea fishing trawlers drag nets weighted with heavy chains across seamounts to catch schools of fish that congregate around them. In the process the nets destroy long-lived and slow-growing corals, sponges, and other invertebrates. Once these underwater communities are disrupted, it can take hundreds, even thousands, of years for them to reestablish themselves.

We turn a ghostly greenish blue in the light, kept dim so we can see outside. Clear, pulsing

**Society Grant** Gregory Stone's seamount research was funded in part by your Society membership.

*A diver explores a shallow, coral-encrusted seamount slope near Raja Ampat, Indonesia (left); the remotely operated vehicle can descend to survey deeper reaches. An abandoned trawl net blankets part of the El Bajo Seamount in Mexico's Gulf of California, destroying corals. Overfishing has depleted the once vibrant ecosystem here and at seamounts worldwide.*

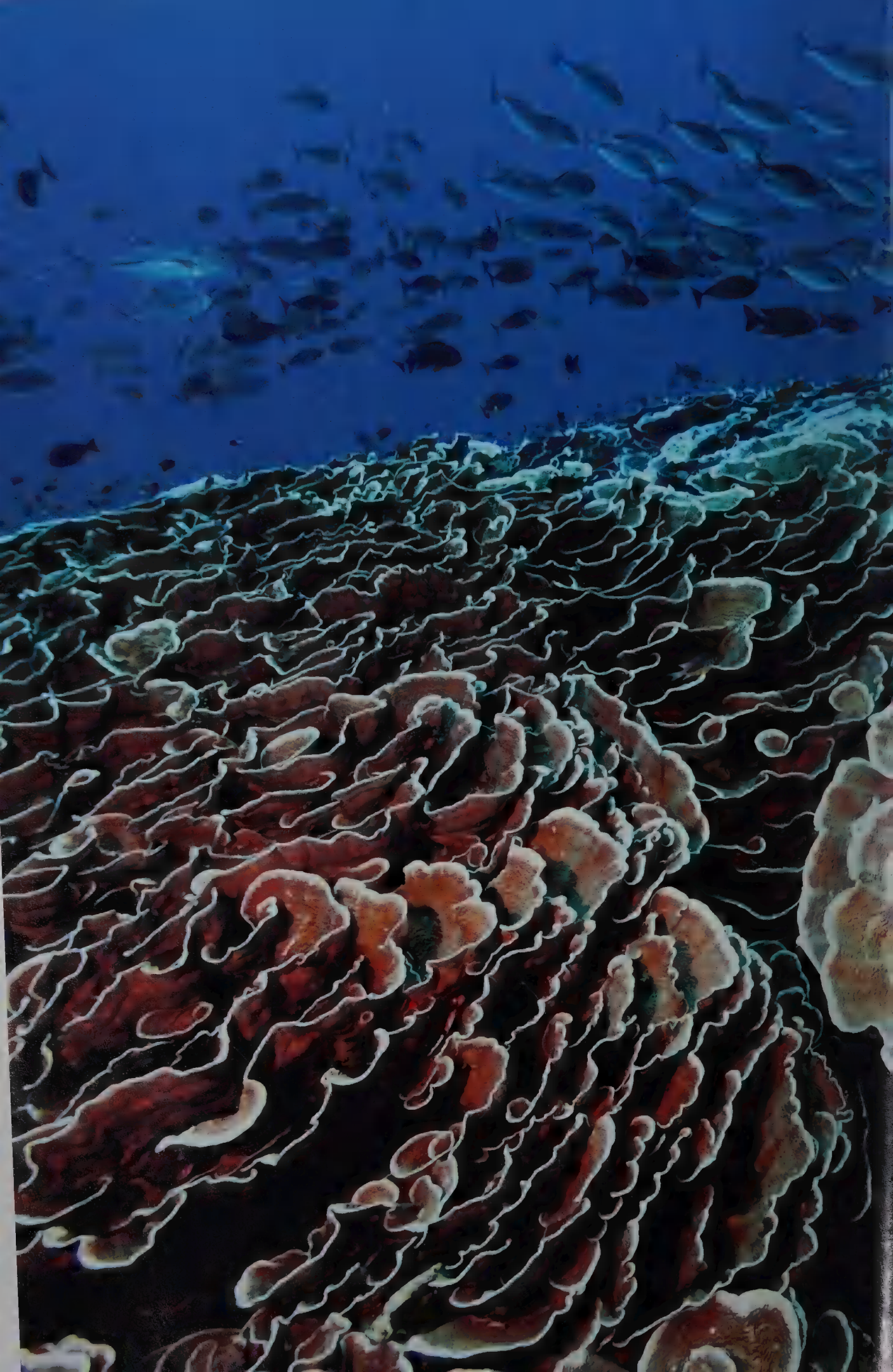
jellies glide gently in the dark, bouncing off the sub in every direction. A black-and-white manta ray flexes its wings and soars past for a look. We are still in the photic zone, where sunlight penetrates and provides energy for countless microscopic, photosynthetic ocean plants that create much of the Earth's oxygen. Then we descend farther. The ocean is pitch-black.

At about 700 feet the sub's dazzling lights bring the bottom into view. Klapfer maneuvers deftly, but the current is strong, and we may not be able to stay down for too long. Suddenly something just beyond the lights rises from the otherwise featureless seafloor. We joke that maybe we've found a new wreck, but instead it is a volcanic remnant, perhaps millions of years old. Within minutes a muffled whir tells us that Klapfer has reversed the thrusters and is bringing the sub into position to hover inches from the bottom, inside an ancient, circular vent of the now extinct volcano that forms Las Gemelas. Its sculptured walls look like the facade of a deep-sea cathedral.

This is the last of our five dives in *DeepSee*, after a week of calling Las Gemelas home. During our time here, we have observed the animals that live on the summit of this seamount and the pelagic, or marine, invertebrates that occupy the water column around it.

Our sub surfaces after five hours—all too soon. We stow our gear aboard *Argo* and begin the long haul back to our landlocked lives, where we will analyze our data and add one more piece to the puzzle of our global ocean. ☐

Take a voyage of discovery of our ocean planet with scientist Robert Ballard in *Alien Deep*, a five-part series airing in September on **National Geographic Channel.**



*An expanse of cabbage coral attached to the slope of a seamount near Raja Ampat provides shelter for crabs, shrimps, and other animals. Passing schools of fish may feed on these invertebrates as well as on plankton brought up by strong currents.*

YEMEN

# Days of Reckoning

*Faced with rebels, refugees, and al Qaeda, the nation is on the brink of a new beginning—or deeper divisions*

Lights atop the 300-foot minarets at four-year-old al Saleh Mosque glow during a storm in Sanaa. The $60 million house of worship is Yemen's largest and most extravagant, named for Ali Abdullah Saleh, who stepped down in February after 33 years as president. It opened with claims of promoting moderate Islam. But militant groups have only gained strength.

A shattered family mourns 15-year-old Nadaa Showqi Abduallah Hussein, her body swathed in cloth. She was killed by a sniper in the southern port city of Aden during a March clash between gunmen and government forces. "What happened to her makes all people cry," says her father, Showqi Abduallah Hussein (at right, in head scarf). "She had no enemies."

A lieutenant patrols the pink barracks of Yemen's female counterterrorism unit at a Sanaa base. "The color on the walls was our idea," says one officer. "We fought for the color." Some 1,500 women serve in police and counterterror units. They're crucial in an ultraconservative culture where men cannot check female suspects—or those disguised as women.

Eleven-year-old Turki Ahmed flies a kite amid the rubble of Sadah, a northern antigovernment stronghold near Yemen's border with Saudi Arabia. His ten-year-old cousin Afnan Hussein Ali Jaralla al Tamani scampers behind him. Since 2004 an insurgency in the north has destroyed much of the city, left hundreds dead, and driven more than 100,000 from their homes.

BY JOSHUA HAMMER
PHOTOGRAPHS BY STEPHANIE SINCLAIR

The man was crucified, Um Mohammed said, her black eyes peering out through the slit in her black *niqab*. She was a widow in her 30s with two small children. Fleeing danger and chaos, she found herself this morning in the faculty room of an elementary school in the Crater neighborhood of Aden, a port city in south Yemen. Her children—Ibrahim, ten, and Fatima, seven—both sat cross-legged on wooden chairs beside their mother and shyly watched me.

The school had been converted into a center for displaced people—some 530 men, women, and children on three floors overlooking a litter-filled dirt courtyard. Undeterred by the squalor and fetid heat, young boys kicked soccer balls in the corridors. Dozens of new arrivals waited to be registered by a volunteer tapping their names into a dusty laptop.

Um Mohammed was too frightened to divulge her real name but not too frightened to speak her mind. She showed me a cell phone video she had made three weeks earlier, this past January, during a trip home to Zinjibar to retrieve some belongings. It showed a bearded man hanging from a lamppost, his hands nailed to a wooden crossbeam. Speaking in a shrill voice muffled by the black cloth in front of her face, she said that the man, an al Qaeda operative, had been accused of spying for the Yemeni government. "He hung there for three days. It was a warning to the people: Every traitor should be killed like this."

Other countries in the Middle East suffered more violence than Yemen during the Arab Spring—Muammar Qaddafi's Libya, Bashar al Assad's Syria—but this country of 24 million has emerged from its popular revolution in a deeply precarious condition. In the far north, al Houthis, a Shiite-based political movement, waged a six-year insurrection against the Yemeni government and now controls a large swath of territory—though its leaders have signaled a desire to participate in a national dialogue. In the far south, Aden and its surrounding districts are under siege by al Hirak, a separatist movement that wants independence for the region.

And east of Aden, al Qaeda in the Arabian Peninsula (AQAP) is mounting a campaign of insurgency and terror. It was formed in 2009 through a merger of Yemeni and Saudi branches of al Qaeda and gained force during the popular uprising that convulsed Yemen between January and November 2011.

After mass protests calling for President Ali Abdullah Saleh to resign, the United States and Persian Gulf nations pressed the weakened leader to step down. With the government in tatters and the army divided and demoralized, al Qaeda began recruiting new followers with promises of glory fighting the U.S.-backed army. In May 2011 al Qaeda militants drove government forces out of Zinjibar, the capital of Abyan Province, a 150-mile-long sliver of mountain redoubts and strategic coastline along the Arabian Sea.

More than 130,000 refugees from Abyan have poured into Aden during the past year. AQAP extremists now control parts of three provinces

Wearing his ceremonial dagger, Yemen's top tribal leader, Sheikh Sadiq al Ahmar, and his tribesmen stand by his Sanaa residence, with its portrait of al Ahmar's politician father. The sheikh's followers fired on government troops in May 2011; they retaliated, attacking his home.

and have carried out terrorist attacks in other regions, including the oil-rich eastern province of Hadramawt and the capital, Sanaa. Islamist gunmen patrol the region in trucks draped in black banners that proclaim, "There is no other God but Allah."

So far the U.S. has spent hundreds of millions of dollars arming and training Yemen's Central Security Forces to fight al Qaeda as well as carrying out air strikes against militant leaders. In September 2011 a drone attack killed Sheikh Anwar al Awlaki, the U.S.-born militant who galvanized Nidal Malik Hasan, the Fort Hood shooter, and Umar Farouk Abdulmutallab, the "underwear bomber." This past May the CIA used a Saudi double agent to foil an AQAP plot to blow up a U.S. airliner. Al Qaeda struck back soon after, when a suicide bomber blew himself up in Sanaa, killing more than 90 soldiers.

Besides al Qaeda and the separatist factions, Abed Rabbo Mansour Hadi—the former vice president who was elected president in February 2012 for a two-year transition period—faces dire domestic problems. With a per capita income of $1,140, Yemen is one of the poorest countries in the Arab world. Over half a million desperate Somali immigrants are burdening the already overstrained economy. Yemen's water is running out, and its oil supplies are expected to be exhausted by 2022. Its population is both young and growing; unemployed youths are a threat to stability. Hadi has moved boldly to solidify control over the military, sideline Saleh-family politicians, and begin a national dialogue on civil society, but his hold on power remains tenuous.

In the face of these grave challenges, what kind of society will take root in Yemen? Will it become a modern nation, grounded in the rule of law? Or an even more anarchic state, torn by tribal, ethnic, and religious conflict and a threat to Western security?

YEMEN HAS NOT always been so blighted. The Greek-Roman geographer Ptolemy called the region Eudaimon Arabia—Happy Arabia—and marveled at its stability and prosperity.

People still assemble and pray near Sanaa University's southern gate, dubbed Change Square in early 2011, when it became a gathering place for thousands of Arab Spring protesters opposing the Saleh regime. Saleh stepped down, but Yemen's woes remain.

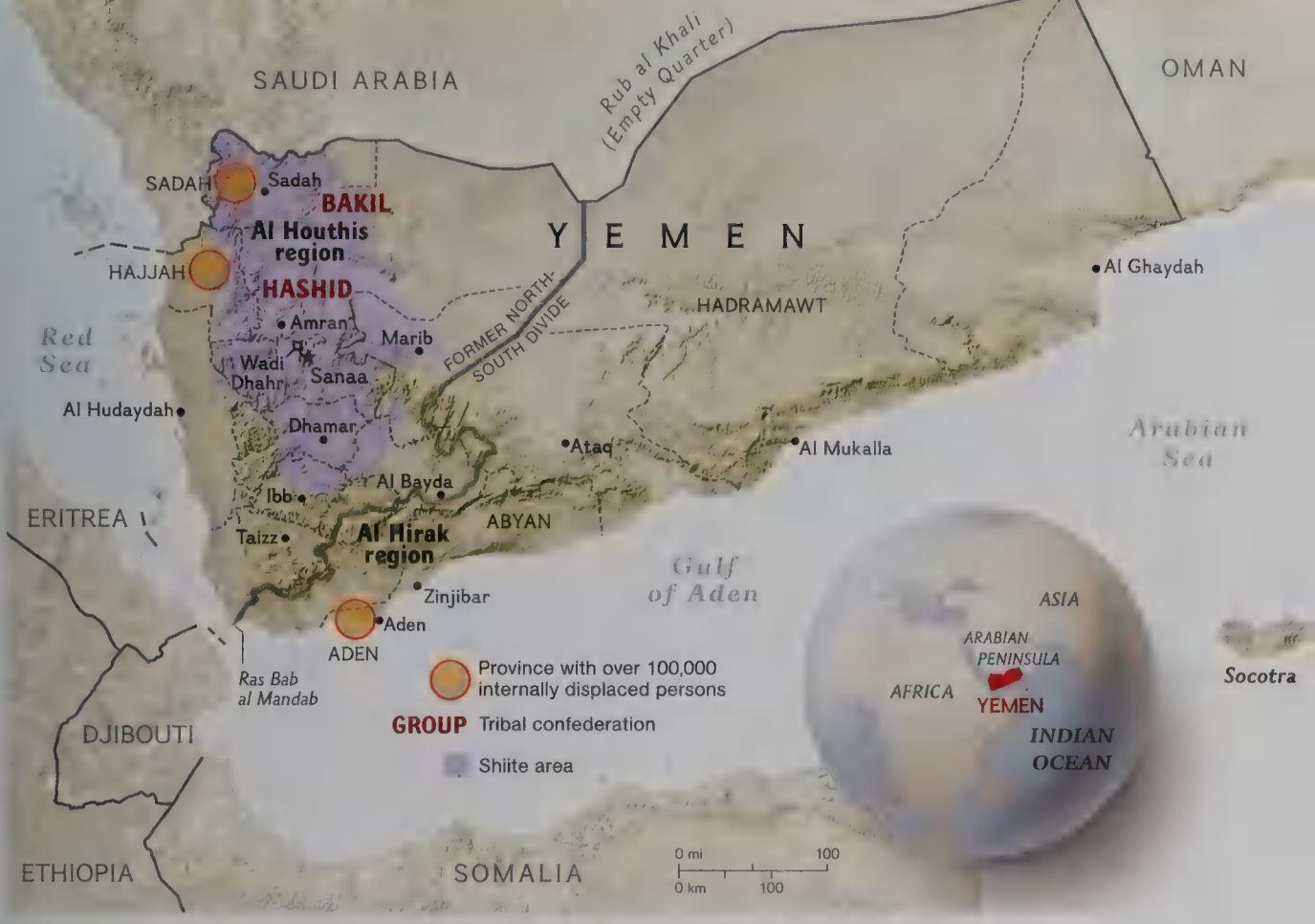
Pre-Islamic Sabaean rulers expanded their empire through the Horn of Africa and in the second century A.D. built architectural wonders such as the skyscraper palace of Ghumdan, celebrated by a medieval Arab poet as "twenty floors wound with a turban of white cloud and girdled in alabaster."

After Islam spread to the region in the 630s, Happy Arabia fluctuated between periods of unity and deep division. In the 19th century the Ottomans in the north and later the British in the south tried to impose their authority, only to be confounded by Yemen's defiant tribes and its geography—narrow valleys, dizzying mountain ranges, and the Empty Quarter, one of the world's most inhospitable deserts, along its border with Saudi Arabia.

Saleh—a barely educated, wily army officer—was the latest leader to try to tame Yemen. When he rose to power in 1978, he ruled North Yemen; 12 years later he oversaw the unification of the north and the south. He forged ties with tribal sheikhs and Islamic leaders, buying loyalty with bribes and patronage. He cozied up to Saddam Hussein (Yemenis dubbed him "Little Saddam"), and after 9/11 he made overtures to the U.S. He also packed the military and intelligence services with family members and allowed corruption to infuse every facet of Yemeni life. In February 2012 Saleh stepped down, signing a deal that divided the government between his party and a coalition of five opposition groups. Saleh, his kin, and his security forces were guaranteed immunity from prosecution. Now in Sanaa, he continues to stir up trouble—inciting loyalists, even denouncing the new government as "thugs" on the TV stations owned by his party.

"QAT IS BETTER THAN HONEY," exclaimed Abdullah al Kholani, 60, with a grin. "We would

*Veteran foreign correspondent Joshua Hammer specializes in Africa and the Middle East. Stephanie Sinclair's June 2011 coverage of child brides won first place in the 2012 World Press Photo contest.*




Yemen's tribes have been a defining force, often outweighing the power of the state. Tribes are strongest in the north, a bastion of Shiite Islam in a country that is otherwise Sunni. The population, half under age 18, swells yearly with refugees from Ethiopia and Somalia.

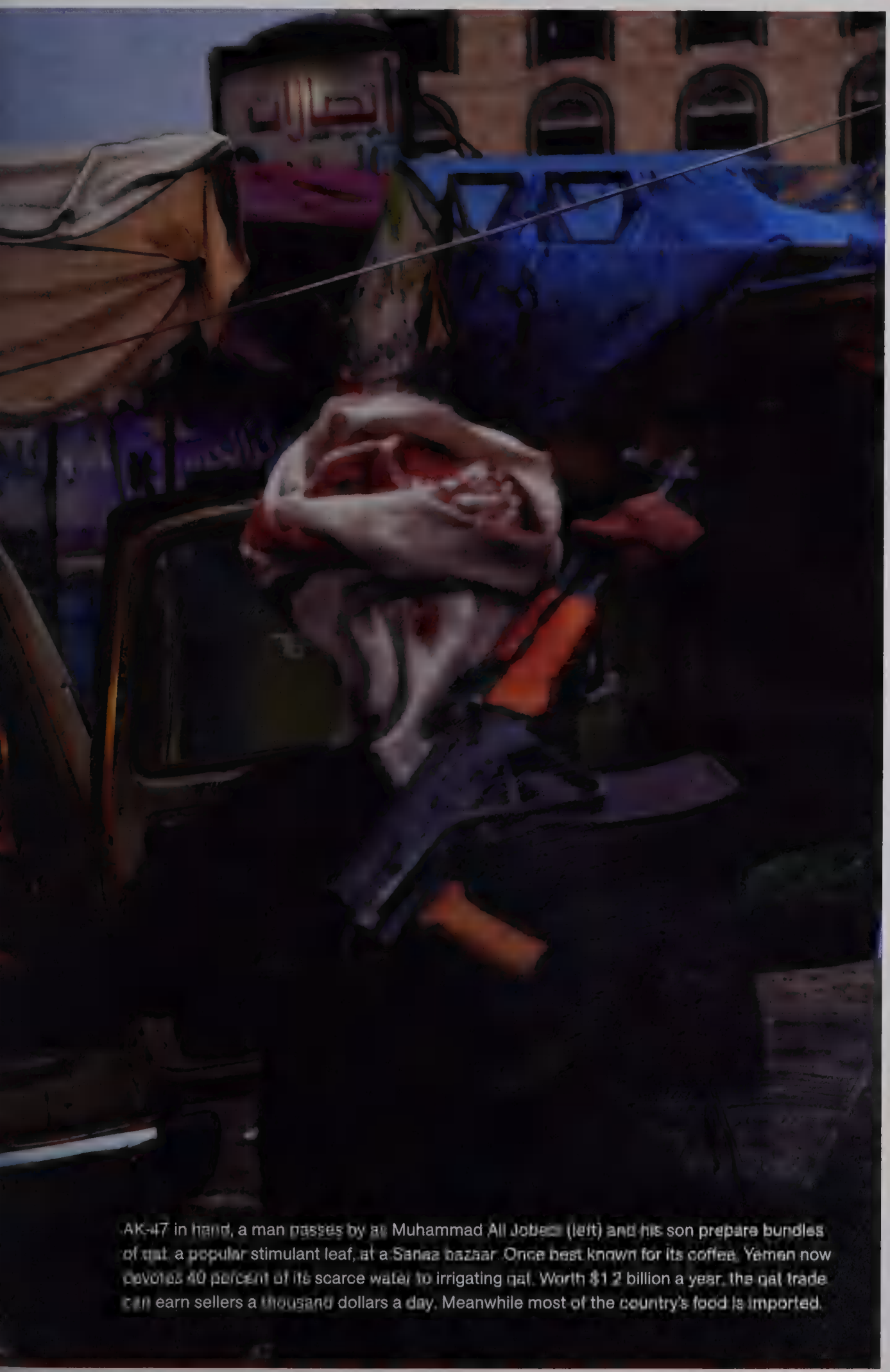
stop eating before we would stop chewing." Al Kholani was a squat man with a red-and-white kaffiyeh bundled at a jaunty angle atop his head. He had deep-set eyes, a hawk nose, and a snaggletooth that extended over his lower lip. His hands were rough and stained green from plucking qat leaves. His beige vest and off-white abaya were in need of a wash. He was "a man of the soil," al Kholani told me, "and proud of it." He spoke Arabic in guttural, high-pitched bursts that my interpreter found barely coherent. That's because the farmer's mouth was stuffed with qat.

Al Kholani led me from the stone house where he and his wife had raised their six children along a bone-dry irrigation ditch to a clearing amid a jungle of slender, light brown trees. We paused to admire one that rose to about 40 feet, with a trunk as big as that of a medium-size oak, its extended branches thick with small, oval leaves. "It's about 200 years old," al Kholani said.

We were in Wadi Dhahr, a canyon northwest of Sanaa lined with vertiginous sandstone walls. Dar al Hajr, the summer retreat of the last ruling imam of Yemen, a marvel of stained-glass windows and cool stone passageways, rose on an outcropping behind us. Al Kholani, whose family has farmed qat here for generations, boasted that his leaf was the strongest. "You chew that, and you will be awake for three days," he said, laughing, as he offered me a clump of leaves from the ancient tree. They were bitter and brought on an intense thirst, which I quenched with a long swig of mineral water.

Al Kholani cultivates several acres of qat in two plots. He sells two harvests a year to a wholesaler who distributes the leaves to markets across Sanaa. The crop brings about $4,000 a year—nearly four times the average per capita income. And there's a side benefit: Al Kholani gets to chew as much qat as he wants, starting early in the morning and continuing late into the night. "Qat is much better than whiskey, much better than hashish, because it keeps you working," he said, shoving another fistful of leaves into his mouth. "It gives you energy. I chew qat when I don't have any rials in my pocket, and it keeps

NGM MAPS. SOURCE: IDP DATA AS OF MARCH 2012 FROM THE UNITED NATIONS HIGH COMMISSIONER FOR REFUGEES



AK-47 in hand, a man passes by Ali Muhammad Ali Jobeni (left) and his son prepare bundles of qat, a popular stimulant leaf, at a Sanaa bazaar. Once best known for its coffee, Yemen now devotes 40 percent of its scarce water to irrigating qat. Worth $1.2 billion a year, the qat trade can earn sellers a thousand dollars a day. Meanwhile most of the country's food is imported.

USA

Preparing to leave for school, 13-year-old Alhanouf al Tamari peeks out from her *niqab*. For the past three years she has lived with her parents and six siblings in a single room in Sadah - all that was left of the family home after fighting between government forces and insurgents virtually destroyed it. They're the lucky ones. Others, displaced by violence, make do in tents.

me happy. If I don't have something to eat, no problem." Al Kholani told me that he ignored the turmoil in Sanaa last year. "I care only about my farm," he said. But because of the protests and gun battles, "people were not chewing as much as usual, and business was bad. Inshallah, it will get better."

At least ten million Yemenis—40 percent of the population—chew qat four or more hours a day, according to surveys. The activity is a drain on income and, despite al Kholani's insistence that it keeps you working, productivity. Qat contains an alkaloid that breaks down to form a chemical closely related to adrenaline. It imparts an urge to talk and a general sense of well-being, but if consumed in excess, as I learned, it can make you fidgety, restless, sick to your stomach, and unable to sleep.

"Qat is much better than whiskey, much better than hashish, because it keeps you working," al Kholani said, shoving another fistful of leaves into his mouth.

The strongest argument in qat's favor is that it can play a mediating role. A Western diplomat in Sanaa told me that rivals often chewed together during the uprising against Saleh. "You'd go to a qat chew, and somebody from the faction of Ali Mohsin, somebody from Saleh's Republican Guard, who maybe was his cousin, would be there." (Ali Mohsin al Ahmar is a powerful general who defected to the opposition.)

Some of al Kholani's qat goes to the Cairo Street market in northwest Sanaa, a raucous bazaar covered by a corrugated metal roof. In the early afternoon the souk is jammed with people from all walks of life: soldiers, traders, professionals, civil servants, students. Walid al Rami, my government minder, a qat addict with a bleary-eyed look, searched for small, soft leaves and reddish stems—"signs of sweetness and potency," he said. He bought a bundle for the equivalent of $25, enough for the night's chew.

About 40 percent of Yemen's dwindling water resources go to qat irrigation. Ever since the river that ran through al Kholani's farm suddenly dried up, he has had to draw more than 10,000 gallons a month from a deep well to irrigate his qat. In some parts of Sanaa water pipes are dry, and supplies have to be trucked in daily.

Adel al Shujaa runs the Yemeni Anti-Qat Organization in Sanaa. "Those who are against qat nowadays are very few," he said, before rattling off a list of the leaf's negative effects: appetite suppression, malnutrition, a weakened immune system. Al Shujaa has been lobbying the parliament to draft anti-qat legislation, but after a decade of lonely work his only success has been to persuade a single qat farmer to grow coffee and other substitute crops. "I am optimistic that we will succeed at the end of the day," he said. "Christ Jesus, peace be upon him, had very few followers at the beginning, but now his followers are more than two billion."

IN SANAA'S OLD CITY a camel groaned in the semidarkness of a grottolike shop near Bab al Yemen, the only remaining stone archway of the seven that once sealed this 2,500-year-old city from the outside world. With a rope harness tied around its head and hump, the camel was plodding around a cast-iron mill, grinding mustard seeds into oil. It was 8:30 a.m., hours before the start of business in the ancient quarter of the capital, and many residents were still sleeping off the night's qat chew.

The Old City has diminished in size over the past century, and electrification and sewage projects have brought it into the modern world. But in many respects, it remains unchanged, with residential towers of fired brick and alabaster clustered around markets for gold, jewelry, textiles, fresh produce, spices. In a passageway two women wearing traditional Sanaani clothing—body-draping abayas printed with white, black, and red geometric designs—parted to let me pass. An elderly man with coal-blackened eyelids and a wispy white beard slid by, a curved dagger,

or *jambiya,* thrust into his brocaded belt. Not long ago jambiyas showed men's status as tribesmen, judges, and direct descendants of the Prophet Muhammad; each group wore jambiyas with markings that indicated its caste. But Saleh elevated the social status of shopkeepers and tradesmen, a politically astute move that broadened his base of support.

"We still love Saleh," Abdullah, the owner of the mustard-seed mill, told me, proudly pointing to framed photographs of the former president that cover the grimy walls of his shop. Along with Saleh and almost everyone else in the Old City, Abdullah is a Zaidi, an adherent of a moderate sect of Shiite Islam found mainly in Yemen. But commonality of religion only partly explains the allegiance to Saleh.

Traditionally in Yemen, tightly knit tribal groupings have served as states within the state, with arsenals of weapons and a parallel court system ruling on everything from property disputes to murder. Saleh derived support from his alliance with Sheikh Abdullah al Ahmar, the "sheikh of sheikhs," who led the powerful Hashid tribal confederation, one of Yemen's two major tribal groupings, along with the Bakil.

In recent decades education, urbanization, and exposure to the outside world have weakened tribal influences. Many tribesmen no longer unquestionably accept the supreme sheikh's authority, and demands for basic rights and freedoms are growing. In March 2011 after the senior al Ahmar died, his sons rose up against Saleh following a massacre of protesters. The Republican Guard and tribal militias engaged in heavy gun battles in Sanaa, signaling the beginning of Saleh's collapse.

IF ONLY THE CALM AND RESTRAINT of the Old City were the face of Yemen. Today the country's zeitgeist is more accurately embodied in lawless, unstable Aden, the city where al Qaeda suicide bombers struck the U.S.S. *Cole* in 2000. To avoid being kidnapped on roads stalked by mercenary tribesmen and al Qaeda insurgents, I traveled there by plane.

The stench of decay and burning trash filled the torpid air of the once cosmopolitan port city, set on a peninsula of volcanic hills overlooking the Gulf of Aden. Sanitation workers had been on strike for two weeks, and mountains of refuse, picked at by donkeys and goats, lined the roadsides. Graffiti covered the walls—INDEPENDENCE NOW; TELL THE SANAA REGIME TO STOP KILLING THE SOUTH PEOPLE—and flags from the long-defunct People's Republic of South Yemen flew at almost every intersection. Youths with AK-47s manned roadblocks of bricks and concrete in the Maalla neighborhood, a separatist stronghold.

Nasser Saleh Attawil, 62, is the secretary general of a moderate wing of al Hirak, southern Yemen's separatist movement. It was too dangerous to meet at his apartment in Maalla (a teenage separatist had been shot by a sniper in the area the previous day, igniting violent protests), so we talked in the shade of an umbrella at the deserted Elephant Bay Beach Resort. Attawil, a former South Yemen Air Force officer educated in Ukraine when it was part of the Soviet Union, complained that Saleh had given away southern land to northern allies and siphoned oil wealth from southern Hadramawt. Since unification in 1990 and the civil war that followed, Attawil said, "our state, wealth, and identity have all been lost." Like many southerners, he regards north Yemenis with condescension. "We don't carry jambiyas here," he said with a mocking laugh.

Attawil founded his group five years ago as a peaceful movement dedicated to achieving more self-governance for the south, such as the ability to levy taxes and control revenues. But a faction of radical separatists, emboldened by the collapse of central authority, is demanding full independence and, reportedly financed by Iran, has mounted frequent protests and carried out attacks against Yemeni security forces. There have been reports about collaboration between the separatists and al Qaeda, though these seem to be government propaganda aimed at delegitimizing al Hirak's grievances.

While waiting out a sandstorm at the airport in Aden, I fell into conversation with Hussein Othman, a burly 38-year-old sheikh from the al Arwal tribe in eastern Abyan. "I am from the

place where al Qaeda in the Arabian Peninsula began," he told me. He divides his time between Abyan and Sanaa, where he works as a human resources manager for a journalists' cooperative. He enrolled his 16-year-old son in a school in Sanaa to educate the teenager away from al Qaeda's influence.

Othman is trying to mediate between the government and the Islamic militants, many of whom he grew up with or are the children of members of his clan. But the talks aren't going anywhere. Al Qaeda, he said, has demanded that the government enforce sharia and withdraw all remaining troops from the province.

As we talked, Othman toyed with his .32 pistol, which he carries for protection whenever he returns to Abyan. Some insurgents believe he's allied with the government, but Othman insisted that he's neutral. "Tribesmen and Bedouin are always affected by religion. And there is poverty," he said, explaining the militants' appeal. Abyan is one of Yemen's poorest, least developed provinces. "Al Qaeda breeds in this environment," Othman said. As in Afghanistan and Pakistan, drone attacks on suspected militants have sometimes killed civilians, inflaming sentiment against the U.S. and persuading men to join al Qaeda. "The militants are chased by drones. The people see them as heroes," he said.

Strict social codes relegate women to second-class status. Yemen ranks dead last in the World Economic Forum's Global Gender Gap Report.

JUST OVER A HUNDRED MILES northwest of Aden is Taizz, the city that, as the heart of the revolution, stirred hopes for a very different kind of Yemen. Taizz had emerged alongside trade routes to the Red Sea coast to become a center of commerce, industry, and education. Yet this least tribal, most liberal of Yemen's cities was marginalized by Saleh, and it languished. The first protests took place here in February 2011. A year later protest marches were still held every Friday following afternoon prayers. One Friday I watched thousands of men, women, and children waving flags in support of the Syrian opposition and flashing V-for-victory signs.

In Garden City—a pleasant compound of cafés, playgrounds, and an amusement park in the shadow of the Qalat al Qahira, a multiwinged Ottoman citadel perched on a precipice—I met one of the leaders of Taizz's pro-democracy movement, which is now struggling to remain relevant. Belkhis al Abdeli is 31, though at first glance she could pass for a teenager. She's tiny, with chipmunk cheeks and dark eyes framed by a green *hijab,* the head scarf that, unlike the niqab, leaves the face exposed. Nudge al Abdeli onto the subject of politics—or women's rights—and the warm smile disappears. Her eyes flash, and her hand stabs the air as she speaks. "I hate the niqab," she said, adding that she has never accepted the strict social codes that relegate Yemeni women to second-class status. Women, she said, should have the choice to cover their faces or leave them exposed—"but most women in Yemen are not given the choice." Al Abdeli is unmarried and unapologetic. "My relatives say, 'You have no chance of getting married anymore.' It doesn't bother me." She often travels on her own, shrugging off disapproving looks.

By almost all indicators—health, education, and economic opportunity—women fare poorly in Yemen. It has one of the highest rates of child marriage in the world, and 60 percent of Yemeni women are illiterate. Infant mortality rates are also among the world's worst, attributed to the lack of prenatal and postnatal health care. Unlike men, women cannot easily get divorced, and they have limited property and inheritance rights. The country ranks dead last among 135 countries in the World Economic Forum's Global Gender Gap Report.

Al Abdeli is an assistant professor of accounting at a university in Taizz, and she enjoys more

freedoms than most of her peers. She credits this to growing up in Taizz and having an open-minded father who "did not go to university but is knowledgeable about the world." She is also a poet who for years openly expressed her loathing for Ali Abdullah Saleh's regime. "I put some of my dreams in my poetry and implanted them in the minds of my students," she said. When Hosni Mubarak fell in Egypt, al Abdeli had new hope. "I felt definitely we will have a revolution here too. From the first day I wanted to join the protests, but my father advised me not to. He said, 'The regime is bloody.' So I went a few days later."

In a tent camp called Freedom Square, al Abdeli was elected to the leadership council. In April 2011 she started her own movement, the Forum for Change, which grew to include hundreds of members. She organized seminars and led demonstrators through Taizz's streets after Friday prayers. A fiery orator, she spoke passionately of the need to eliminate corruption and patronage and guarantee equal rights for women.

The mood turned ugly on the night of May 29, when unidentified attackers (who many believe were Saleh's security forces) burned down hundreds of tents in Freedom Square and killed 50 protesters. After the massacre the area's most powerful sheikh, Hamoud al Mikhlafi, announced that he would serve as the protesters' protector, and hundreds of militiamen came to Taizz from rural areas to defend them.

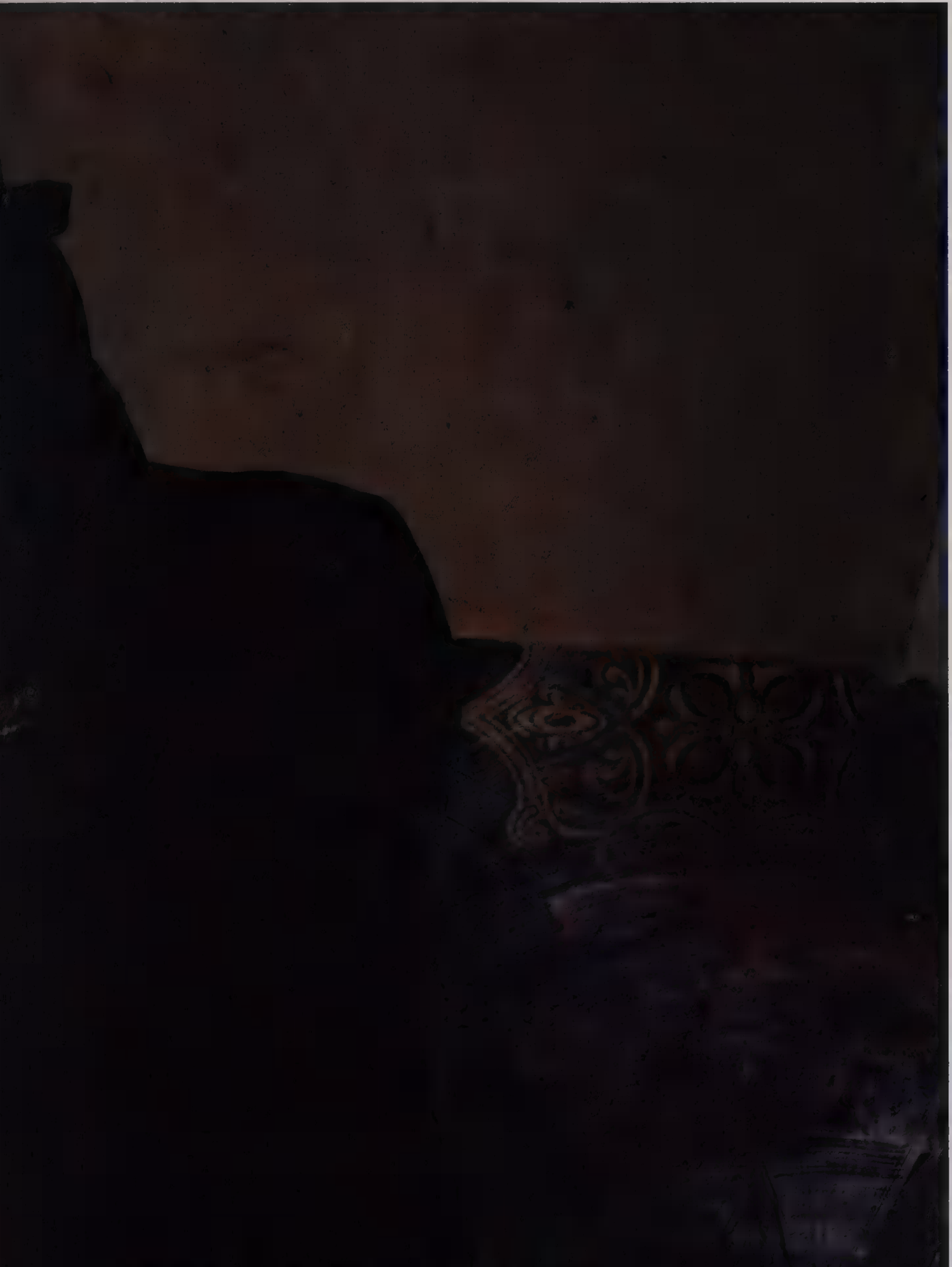
Republican Guards and other pro-Saleh forces attempted to crush the revolt. During that time al Abdeli huddled with her parents and siblings in the basement of the family home while mortar rounds and artillery shells crashed around them.

Now the city that has long been considered Yemen's least tribal finds itself beholden to al Mikhlafi and his brethren. His militias control many streets, and his membership in al Islah, the country's main Islamic party, which includes everyone from Muslim Brotherhood moderates to ultraconservative Salafists, has given the Islamists new prominence: At the Friday afternoon rally I attended, the only speakers were Islamic party members. Secular democrats like al Abdeli are out of the power structure, but she still goes to Freedom Square several times a week. "We wanted a real revolution," she said animatedly.

LEAVING GARDEN CITY, I drove at dusk to al Mikhlafi's hilltop villa, pocked by bullet holes from last year's fighting. A dozen of his guards were patrolling the street in front with AK-47s. Al Mikhlafi was chewing qat in a smoke-filled reception room on the ground floor, crammed with about a hundred qat-chewing tribesmen sitting in two rows facing one another, with their backs to the white walls of the narrow chamber. Weapons were propped up against the walls, and the blue-and-russet carpet was strewn with qat leaves and stems and overflowing ashtrays. Al Mikhlafi led me into a private room across a courtyard to talk.

He had been a security officer in Saleh's government, responsible for gathering intelligence on the regime's foes. "I gave him advice—to consult more with the people, to institute real democracy—but he ignored it," said the sheikh, a handsome man with a patchy black beard, soft eyes, and a helmet of curly gray hair that accentuated the squareness of his head. Al Mikhlafi called himself "a defender of democracy." (He is a cousin of Tawakkol Karman, the Nobel Peace Prize winner.) But the secular democrats of Taizz say that his allegiance to the Islamic party and his pattern of resolving conflicts through displays of force suggest that building a civil society is not foremost on his agenda.

When I was in Taizz, it was a city very much on edge. Men wearing camouflage jackets had recently ambushed and killed a 29-year-old American teacher as he drove to his job at a Swedish-run English-language school and women's education center. Al Qaeda claimed responsibility for the murder, alleging—falsely—that he was a Christian missionary. It was the first time AQAP had carried out a terrorist act in Taizz—and it served as a sign of heightened danger throughout Yemen. Al Abdeli and her pro-democracy movement hope to build a new society based on transparency and the rule of law. But al Mikhlafi and those like him are in charge now. Yemen still belongs to the men with guns. □



Cradled by his mother, Saleem al Harazi lost both eyes to a sniper. The 12-year-old was shot when he joined antigovernment protesters in Sanaa in March 2011. "I loved them and wanted to stand with them," he recalls. "I wanted them to end poverty." They were the last people he ever saw, and he has no regrets: "I am still happy I was able to witness the protests firsthand."

Generators keep lights blazing as relatives and neighbors fete bridegroom Ameen Ararah (in floral head scarf, at center rear), 21, at his wedding in Sanaa's Old City. In a country where nearly half the population lives on $1.45 a day, wedding expenses—which can exceed $5,000—are prohibitive. Many couples now pool resources and marry in groups.

YR
100Fulla

As dusk falls over Sanaa's Fun City amusement park, a mother watches her children spin on a ride featuring an unveiled version of Fulla, a Barbie doll alternative popular among Middle Eastern girls. Moments like this offer relief from troubles, but the "emergence of a new dawn" heralded by Yemen's 2011 peace Nobelist, Tawakkol Karman, eludes much of the country.

# ROMAN

## ROME'S BORDER WALLS WERE THE BEGINNING OF ITS END

# FRONTIERS

TIMGAD, ALGERIA *This triumphal arch awed visitors to the city of Thamugadi, founded by the emperor Trajan around A.D. 100 as a civilian settlement near the fort of Lambaesis. The grooves left by wagon and chariot wheels can still be seen in the stone road.*

[illegible] (PRECEDING PAGES): [illegible] CLARK

HADRIAN'S WALL, ENGLAND *Barbarians would have stared up at this section, which runs along a cliff near the northern town of Once Brewed. In its heyday, the wall was 14 feet high and stretched 73 miles, from coast to coast. A deep ditch reinforced parts of it. Today a walking trail runs alongside it.*

BY ANDREW CURRY
PHOTOGRAPHS BY ROBERT CLARK

Bouncing along a dusty Bavarian logging road, archaeologist Claus-Michael Hüssen keeps his eyes on the tree line to the left, searching for some familiar landmark in the thick forest. Suddenly he pulls the van over and gets out, pausing to pack tobacco into his pipe and consult a 1:50,000-scale survey map.

Head down, pipe in hand, Hüssen—a researcher with the German Archaeological Institute—crosses the road and wades through the thick underbrush. Fifty yards from the road, he nearly misses a low dirt mound about three feet high and six feet across. Littered with flat white stones, it runs in an unnaturally straight line along the forest floor.

Nearly 2,000 years ago this was the line that divided the Roman Empire from the rest of the world. Here in Germany the low mound is all that's left of a wall that once stood some ten feet tall, running hundreds of miles under the wary eyes of Roman soldiers in watchtowers.

It would have been a shocking sight in the desolate wilderness, 630 miles north of Rome itself. "The wall here was plastered and painted," Hüssen says. "Everything was square and precise. The Romans had a definite idea of how things should be." Engineering students measuring another stretch of wall found one 31-mile section that curved just 36 inches.

Hüssen faces north, the Roman Empire at his back. Two hundred yards away, just past a narrow meadow torn up by wild boars and a rushing stream, the next hill rises like a green wall. "Here's the border," he says, "and on the other side is a wonderful view of nothing."

A stunning network of walls, rivers, desert forts, and mountain watchtowers marks Rome's limits. At its peak in the second century A.D., the empire sent soldiers to patrol a front that stretched from the Irish Sea to the Black Sea as well as across North Africa.

Hadrian's Wall, in England, probably the best known segment, was named a UNESCO World Heritage site in 1987. In 2005 UNESCO established a combined site with the 342-mile German frontier. Preservation experts hope to add sites in 16 other countries. The international effort may help answer a surprisingly tricky question: Why did the Romans build the walls? To protect a regime besieged by barbarians, or simply to establish the physical edge of the empire?

The question isn't just academic. Defining and defending borders is a modern obsession too. As politicians have debated building a wall between the United States and Mexico and troops face off across the land-mine-strewn strip of ground between the two Koreas, the realities the Roman emperors faced are still with us. Understanding why the Romans were obsessed with their borders—and the role their obsession played in the decline of the empire—might help us better understand ourselves.

FROM AROUND 500 B.C., Rome expanded continually for six centuries, transforming itself from a small Italian city-state in a rough neighborhood into the largest empire Europe would ever know.

The emperor Trajan was an eager heir to this tradition of aggression. Between 101 and 117, he fought wars of conquest in present-day Romania, Armenia, Iran, and Iraq, and he brutally suppressed Jewish revolts. Roman coins commemorated his triumphs and conquests.

When he died in 117, his territory stretched from the Persian Gulf to Scotland. He bequeathed

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*Andrew Curry, a Berlin-based journalist, frequently writes about history. Robert Clark covered the Staffordshire gold hoard in the November 2011 issue.*

*An iron mask, sheathed in bronze and silver and discovered in the Netherlands, was attached to a cavalry soldier's helmet by a hinge and worn on parade—and perhaps into battle.*

MUSEUM, NIJMEGEN, NETHERLANDS; PHOTOGRAPHED AT TULLIE HOUSE MUSEUM AND ART GALLERY TRUST, CARLISLE, U.K.

## CONSTRUCTED BARRIERS

**Wall** *(limes)*

Of the thousands of miles of frontier, only a fraction were walls, sealing gaps between natural barriers.

**Fortress**

**Tower or fort**

Troops were concentrated in these frontier structures, ultimately making the interior more vulnerable.

## NATURAL BARRIERS

Mountain

Desert

River

Sea

## GROUPS AND REGIONS

Roman Empire, mid-second century A.D.

Barbarian nation **Daci** *(Approximate location)*

Political region GAUL

CALEDONIA
Caledonii
ANTONINE WALL
37 miles
Vindolanda
HADRIAN'S WALL
73 miles
Hibernii
Pons Aelii
(Newcastle)
Irish Sea
IRELAND
HIBERNIA
BRITANNIA
UNITED KINGDOM
North Sea
NETHERLANDS
GERMANIA
Londinium
(London)
Rhine
Saalburg (see art, pag 116–117)
BELGIUM
English Channel
Becheln
Main
Hermunduri
Marco
Mogontiacum (Mainz)
Lutetia
(Paris)
GERMANIC LIMES
(Walls in Germany)
342 miles
Augusta Vindelicorum
(Augsburg)
GERMANY
ATLANTIC OCEAN
FRANCE
GALLIA (GAUL)
SWITZERLAND
ALPS
Burdigala
(Bordeaux)
ITALY
Brigantium
(A Coruña)
Narbo Martius
(Narbonne)
Massilia
(Marseille)
Legio
(León)
PORTUGAL
Tarraco
(Tarragona)
HISPANIA
SPAIN
Mediterranean
Corduba
(Córdoba)
Gades
(Cádiz)
Caesarea
(Cherchell)
Lambaesis
Carthago
(Carthage)
Tingis
(Tangier)
Thamugadi
(Timgad)
Tunes
(Tunis)
FOSSATUM AFRIC
(Barriers in Algeria)
152 miles
ALGERIA
MOROCCO
ATLAS MOUNTAINS
Mauri
Gaetuli
Musulamii
TUNISIA
AFRICA
Grand Erg Oriental desert
Garamant

## TYPES OF FORTIFICATIONS

Walls, military outposts, and frontier cities were all part of Rome's efforts to mark and defend its vast empire.

**Antonine Wall**

Built of stone, turf, and wood in 142, it pushed the northern frontier beyond Hadrian's Wall for some 20 years.

# DEFINING AN EMPIRE

By the middle of the second century, as depicted on this map, the Roman Empire's centuries of relentless expansion had slowed and then stopped. Rome relied on its network of forts, walls, and natural barriers to separate the empire from barbarians, the term for everyone outside its borders. A mixture of diplomacy, trade, and violence was used to keep the frontiers intact. Eventually, barbarian incursions led to the fall of the western part of the empire in the fifth century.

**Lambaesis**
Rome established this military fort in approximately 81. It later served as army headquarters in North Africa.



**Dura-Europos**
The Romans seized this city, on a cliff above the Euphrates River, from the Parthians in the second century A.D.



PRESENT-DAY POLITICAL BOUNDARIES AND NAMES ARE SHOWN. PRESENT-DAY CITY NAMES ARE IN PARENTHESES.

VIRGINIA W. MASON, MATTHEW TWOMBLY, AND AMANDA HOBBS, NGM STAFF

SOURCES: DAVID J. BREEZE, INTERNATIONAL CONGRESS OF ROMAN FRONTIER STUDIES; SIMON JAMES, UNIVERSITY OF LEICESTER, U.K.; MICHEL JANON AND JEAN-MARIE GASSEND, *LAMBÈSE: CAPITALE MILITAIRE DE L'AFRIQUE ROMAINE*

the empire to his adopted son—a 41-year-old Spanish senator, self-styled poet, and amateur architect named Publius Aelius Hadrianus. Faced with more territory than Rome could afford to control and under pressure from politicians and generals to follow in the footsteps of his adoptive father, the newly minted emperor—better known as Hadrian—blinked. "The first decision he made was to abandon the new provinces and cut his losses," says biographer Anthony Birley. "Hadrian was wise to realize his predecessor had bitten off more than he could chew."

The new emperor's policies ran up against an army accustomed to attacking and fighting on open ground. Worse, they cut at the core of Rome's self-image. How could an empire destined to rule the world accept that some territory was out of reach?

Hadrian may simply have recognized that Rome's insatiable appetite was yielding diminishing returns. The most valuable provinces, like Gaul or Hadrian's native Spain, were full of cities and farms. But some fights just weren't worth it. "Possessing the best part of the earth and sea," the Greek author Appian observed, the Romans have "aimed to preserve their empire by the exercise of prudence, rather than to extend their sway indefinitely over poverty-stricken and profitless tribes of barbarians."

The army's respect for Hadrian helped. The former soldier adopted a military-style beard, even in official portraits, a first for a Roman emperor. He spent more than half of his 21-year reign in the provinces and visiting troops on three continents. Huge stretches of territory were evacuated, and the army dug in along new, reduced frontiers. Wherever Hadrian went, walls sprang up. "He was giving a message to expansion-minded members of the empire that there were going to be no more wars of conquest," Birley says.

By the time the restless emperor died in 138, a network of forts and roads originally intended to supply legions on the march had become a frontier stretching thousands of miles. "An encamped army, like a rampart, encloses the civilized world in a ring, from the settled areas of Aethiopia to the Phasis, and from the Euphrates in the interior to the great outermost island toward the west," Greek orator Aelius Aristides noted proudly, not long after Hadrian's death.

That "outermost island" was where Hadrian built the monument that bears his name, a rampart of stone and turf that cut Britain in half. Today Hadrian's Wall is one of the best preserved, well-documented sections of Rome's frontier. Remnants of the 73-mile barrier run through salt marshes, across green sheep pastures, and for one bleak stretch not far from downtown Newcastle, alongside a four-lane highway. Miles of it are preserved aboveground, lining crags that rise high above the rain-swept countryside.

More than a century of study has given archaeologists an unparalleled understanding of Hadrian's Wall. The wall, perhaps designed by Hadrian himself on a visit to Britain in 122, was the ultimate expression of his attempt to define the empire's limits.

In most places the stone wall was an intimidating 14 feet tall and 10 feet wide. Traces of a 9-foot-deep ditch running the length of the wall are still visible today. In the past few decades excavations have uncovered pits filled with stakes between ditch and wall, one more obstacle for intruders. A dedicated road helped soldiers respond to threats. Regularly spaced gates were supported by watchtowers every third of a mile.

A couple miles behind the wall, a string of forts was evenly spaced half a day's march apart. Each fort could house between 500 and 1,000 men, capable of responding quickly to any attacks. In 1973 workers digging a drainage ditch at Vindolanda, a typical frontline fort, uncovered piles of Roman trash under a thick layer of clay. The wet layer held everything from 1,900-year-old building timbers to cloth, wooden combs, leather shoes, and dog droppings, all preserved by the oxygen-free conditions.

Digging deeper, excavators came across hundreds of fragile, wafer-thin wooden tablets covered in writing. They provide day-to-day details of life along Hadrian's Wall: work assignments, duty rosters, supply requests, personal letters. There is even a birthday party invitation from one officer's wife to another, the earliest surviving

example of women's handwriting in Latin.

The tablets suggest that watching over the "wretched little Britons," as one Vindolanda writer describes the locals, was no picnic, but the fort wasn't exactly a hardship post. Some soldiers lived with their families—dozens of children's shoes, including baby booties, are among the footwear recovered. And the wall's patrollers ate well: Bacon, ham, venison, chicken, oysters, apples, eggs, honey, Celtic beer, and wine were on the menu. There was even *garum,* a fermented fish concoction that was the Roman version of Worcestershire sauce. Homesick soldiers received care packages too. "I have sent you…socks…two pairs of sandals and two pairs of underpants," writes one concerned correspondent.

Scholars today ask a key question that must have crossed the minds of Roman soldiers shivering through long watches in the English rain: What were they doing there in the first place? The scale of the wall and its system of ditches, ramparts, and roads suggest that the enemy could be deadly.

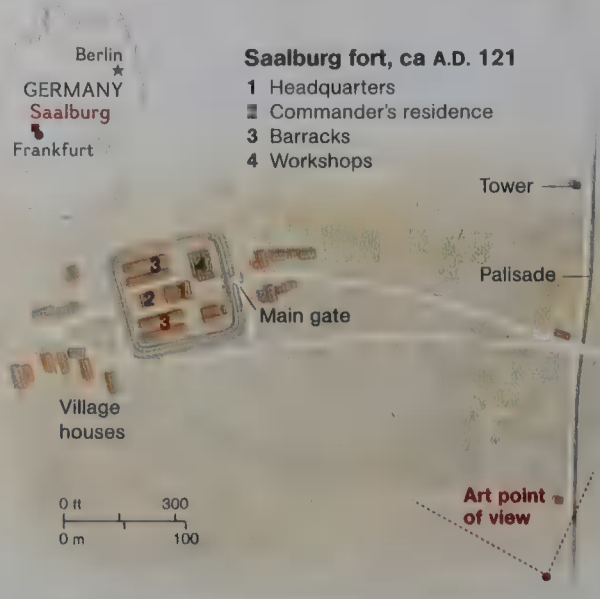
Yet reports from Vindolanda hardly portray a garrison under pressure. Aside from a few scattered clues—like the tombstone of luckless centurion Titus Annius, who was "killed in the war"—there are no direct references to fighting anywhere on the British frontier. The big building project to the north isn't even mentioned. "You get a sense something's up. Colossal amounts of supplies are being ordered," says Andrew Birley, director of excavations at Vindolanda and Hadrian biographer Anthony Birley's nephew. "But they don't refer to the wall itself."

If the walls weren't under constant threat, what were they for? By bringing the sheer scope of the Roman frontier into focus, the effort to create a multinational UNESCO heritage site may help answer the question. Ever since British

**BECHELN, GERMANY** ***Only a few stone foundations remain from the more than 800 watchtowers built by Roman soldiers along 342 miles of the frontier linking the Rhine and Danube Rivers.***

## A TRAVELING EMPEROR

Hadrian spent more than half of his 21-year reign on the road, overseeing the construction of new cities and frontier fortifications. Here he is shown on horseback with outstretched arm, ruling in front of his Praetorian Guard to inspect the Saalburg fort while touring the German frontier around 121.




FERNANDO G. BAPTISTA AND AMANDA HOBBS, NGM STAFF. ART: JAIME JONES
SOURCES: CARSTEN AMRHEIN, SAALBURG ROMAN FORT ARCHAEOLOGICAL PARK; JON C. N. COULSTON, UNIVERSITY OF ST. ANDREWS, SCOTLAND

antiquarians organized the first scientific excavations along Hadrian's Wall in the 1890s, historians and archaeologists have assumed Rome's walls were military fortifications, designed to fend off barbarian armies and hostile invaders.

For decades arguments focused on tactical details: Did soldiers stand along the wall to rain spears and arrows down on invaders or sally forth to engage the enemy in the field? The trenches of WWI—and the deadly back-and-forth battling of WWII—did little to change the prevailing view of the ancient frontier as a fixed barrier separating Rome from hordes of hostile barbarians.

Archaeologists studying the frontiers in the 1970s and '80s later found that the Iron Curtain

dividing Europe had shadowed their view of the distant past. "We had in Germany this massive border, which seemed impenetrable," says C. Sebastian Sommer, chief archaeologist at the Bavarian State Preservation Office. "The idea was here and there, friend and foe."

Today a new generation of archaeologists is taking another look. The dramatic, unbroken line of Hadrian's Wall may be a red herring, a 73-mile exception that proves an entirely different rule. In Europe the Romans took advantage of the natural barriers created by the Rhine and Danube Rivers, patrolling their waters with a strong river navy. In North Africa and the eastern provinces of Syria, Judaea, and Arabia, the desert itself created a natural frontier.

Military bases were often ad hoc installations set up to watch rivers and other key supply routes. The Latin word for frontier, *limes* (LEE-mess), originally meant a patrolled road or path. We still use the term: Our "limits" comes from *limites,* the plural of limes.

Outposts on rivers like the Rhine and Danube or in the deserts on Rome's eastern and southern flanks often resemble police or border patrol stations. They would have been useless against an invading army but highly effective for soldiers nabbing smugglers, chasing small groups of bandits, or perhaps collecting customs fees. The thinly manned walls in England and Germany

TIMGAD, ALGERIA *Rome imposed its sense of order all across the empire. The town of Thamugadi was laid out on a grid-style plan and included a market (at center), ceremonial gates, more than a dozen bath complexes, a library, and a theater that could seat 3,500.*

*Roman soldiers went into battle with a shield, a spear to throw at close range, and a short sword for stabbing or slashing, as shown on this pedestal found in Mainz, Germany. The dragon's head would have been carried into battle on a pole, with a fabric body attached. Otherwise, the dragon would be kept in the central building of a frontier fort.*

MAINZ [illegible] MUSEUM (PEDESTAL); [illegible] BUREAU, ON VIEW AT [illegible] STATE MUSEUM, EHRENBREITSTEIN [illegible], GENERAL [illegible] HERITAGE; [illegible] GERMANY [illegible]

were similar. "The lines were there for practical purposes," says Benjamin Isaac, a historian at Tel Aviv University. "They were the equivalent of modern barbed wire—to keep individuals or small groups out."

Isaac argues that the frontiers resembled certain modern installations more than thick-walled medieval fortresses: "Look at what Israel's building to wall off the West Bank. It's not meant to keep out the Iranian army, it's made to stop people from exploding themselves on buses in Tel Aviv." Warding off terrorists may not have motivated the Romans, but there were plenty of other factors—as there are today. "What the United States is planning between itself and Mexico is substantial," says Isaac, "and that's just to keep out people who want to sweep the streets in New York."

More archaeologists are endorsing that view. "Isaac's analysis has come to dominate the field," says David Breeze, author of the recent *Frontiers of Imperial Rome*. "Built frontiers aren't necessarily about stopping armies but about controlling the movement of people." The Roman frontier, in other words, is better seen not as an impervious barrier sealing Fortress Rome off from the world but as one tool the Romans used to extend influence deep into *barbaricum*, their term for everything outside the empire, through trade and occasional raids.

FOR CENTURIES emperors used a mix of threats, deterrence, and outright bribery to secure peace. Rome negotiated constantly with tribes and kingdoms outside its frontier. Diplomacy created a buffer zone of client kings and loyal chieftains to insulate the border from hostile tribes farther afield. Favored tribes earned the right to cross the frontier at will; others could bring their goods to Roman markets only under armed guard.

Loyal allies were also rewarded with gifts, weapons, and military assistance and training. Friendly barbarians sometimes served in the Roman army; after 25 years, they retired as Roman citizens, free to settle anywhere in the empire. Vindolanda alone was home to units recruited from what are now northern Spain, France, Belgium, and the Netherlands. Iraqi bargemen once sailed England's rivers under the banner of Rome, and Syrian archers watched over the bleak countryside.

Trade was also a foreign policy tool: The Roman-Germanic Commission in Frankfurt, part of the German Archaeological Institute, has a database of more than 10,000 Roman artifacts found beyond the limes. Weapons, coins, and goods like glass and pottery show up as far away as Norway and modern-day Russia.

Roman foreign policy wasn't all carrots. Revenge was also a favorite tactic, and the legions were eager to take the fight beyond the frontier.

They spent seven years avenging one disastrous defeat suffered in A.D. 9 in Germany. The historian Tacitus explains that when victorious on the battlefield, General Germanicus "took his helmet off his head and begged his men to follow up the slaughter, as they wanted not prisoners, and the utter destruction of the nation would be the only conclusion of the war."

Hadrian lashed out at troublesome populations too. In 132 he suppressed a Jewish revolt in a ruthless, protracted campaign. One Roman historian claimed the fighting left half a million Jews dead and added, "As for the numbers who perished from starvation, disease, or fire, that was impossible to establish." Survivors were enslaved or expelled. The name of the province was changed from Judaea to Syria-Palaestina to wipe away all traces of the rebellion.

Word of such brutality surely made Rome's enemies think twice before crossing the line. To the Romans, slaughter and genocide were an important part of keeping the empire secure. "The Pax Romana isn't simply won after a series of battles," says Newcastle University archaeologist Ian Haynes. "Rather, it's asserted over and over in brutal ways."

JUST AS HADRIAN'S WALL shows the Roman frontier at its strongest, an abandoned fortress on the Euphrates River vividly captures the moment the borders began to collapse. Dura-Europos was a fortified city on the frontier between Rome and Persia, its greatest rival. Today Dura sits about 25 miles from the Syrian border with Iraq,

an eight-hour bus ride through the desert from Damascus. It first came to light in 1920, when British troops fighting Arab insurgents accidentally uncovered the painted wall of a Roman temple. A team from Yale University and the French Academy put hundreds of Bedouin tribesmen to work with shovels and picks, moving tens of thousands of tons of sand with the help of railcars and mine carts. "At times it was like the Well of Souls scene from *Indiana Jones*," says University of Leicester archaeologist Simon James.

Ten years of frenzied digging uncovered a third-century Roman city frozen in time. Fragments of plaster still cling to mud-brick and stone walls, and the rooms of palaces and temples—including the world's oldest known Christian church—are tall enough to walk through and imagine what they looked like when they had roofs.

Founded by Greeks around 300 B.C., Dura was conquered by the Romans nearly 500 years later. Its tall, thick walls and perch above the Euphrates made it a perfect frontier outpost. The northern end was walled off and turned into a Roman-era "green zone" with barracks, an imposing headquarters for the garrison commander, a redbrick bathhouse big enough to wash the dust off a thousand soldiers, the empire's easternmost known amphitheater, and a 60-room palace suitable for dignitaries "roughing it" in the hinterlands.

Duty rosters show at least seven outposts reported to Dura. One of the outposts was staffed by just three soldiers; another lay nearly a hundred miles downstream. "This was not a city under constant threat," James told me when I visited, before the political situation in Syria deteriorated and made excavation impossible. We sat amid the ruins and watched orange gas flares from Iraqi oil wells flicker on the horizon. "Soldiers here were probably busier policing the

*This fragment of a hand-painted glass vessel was found near Hadrian's Wall, broken in two pieces. The glass has been attributed to workshops in Germany, evidence of widespread trade.*

ARTIFACT FROM VINDOLANDA CHARITABLE TRUST, BARDON MILL, U.K.

QASR BSHIR, JORDAN *Built around A.D. 300, this cavalry outpost on the edge of the desert is one of the world's best preserved Roman forts. With between 70 and 160 horsemen, the fort kept Arab nomads from attacking caravans carrying frankincense and myrrh.*

locals than defending against raids and attacks."

The quiet didn't last. Persia emerged as a major threat along the empire's eastern border a half century after the Romans seized Dura. Beginning in 230, war between the rivals raged across Mesopotamia. It was soon clear the frontier strategy that had served Rome for more than a century was no match for a determined, sizable foe.

Dura's turn came in 256. Working with a Franco-Syrian team of archaeologists interested in the site's pre-Roman history, James has spent ten years unraveling the walled city's final moments. He says the Romans must have known an attack was imminent. They had time to reinforce the massive western wall, burying part of the city—including the church and a magnificently decorated synagogue—to form a sloping rampart.

The Persian army set up camp in the city cemetery, a few hundred yards from Dura's main gate. As catapults lobbed stones at the Romans, the Persians built an assault ramp and dug beneath the city, hoping to collapse its defenses. Dura's garrison struck back with tunnels of their own.

As fighting raged on the surface, James says, a squad of 19 Romans broke through into a Persian tunnel. A cloud of poison gas, pumped into the underground chamber, suffocated them almost instantly. Their remains are some of the oldest archaeological evidence of chemical warfare. James believes the bodies, found 1,700 years later, stacked in a tight tunnel, were used to block the tunnel while the Persians set it on fire.

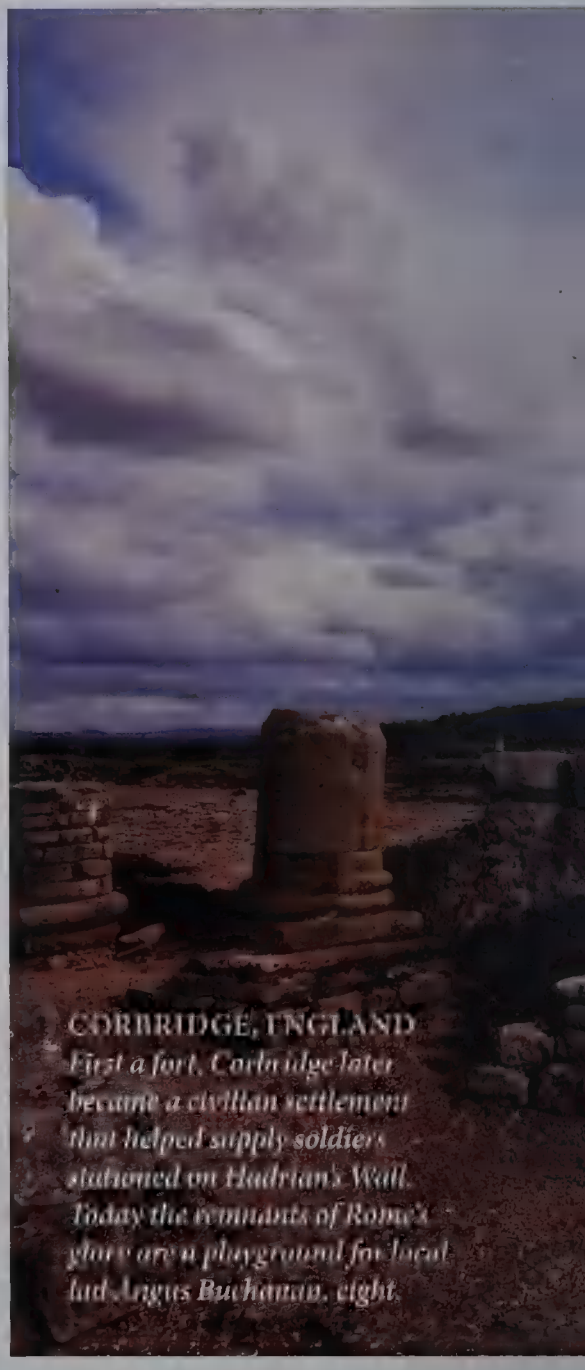
The Persians failed to topple Dura's wall but eventually succeeded in taking the city, which was later abandoned to the desert. Surviving defenders were slain or enslaved. Persian armies pushed deep into what had been Rome's eastern provinces, sacked dozens of cities, and overpowered two emperors before capturing a third, the hapless Valerian, in 260. The Persian king, Shapur, reportedly used Valerian as a footstool for a while, then had him flayed and nailed his skin to a wall.

The crisis was a turning point. Around the time Dura fell, the careful balance of offense, defense, and sheer intimidation along the frontier fell apart.

For nearly 150 years the border had helped Rome ignore a painful reality: The world beyond the walls was catching up, in part thanks to the Romans themselves. Barbarians who served in the Roman army brought back Roman knowledge, weapons, and military strategy, says Michael Meyer, an archaeologist at Berlin's Free University.

While Rome looked the other way, barbarian tribes grew bigger and more aggressive and coordinated. When troops were pulled from across the empire to beat back the Persians, weak points in Germany and Romania came under attack almost immediately.

Hadrian's legacy was doomed. "The tragic point of their strategy is that the Romans



CORBRIDGE, ENGLAND
*First a fort, Corbridge later became a civilian settlement that helped supply soldiers stationed on Hadrian's Wall. Today the remnants of Rome's glory are a playground for local lad Angus Buchanan, eight.*

concentrated military force at the frontier," Meyer says. "When the Germans attacked the frontier and got in behind the Roman troops, the whole Roman territory was open." Think of the empire as a cell, and barbarian armies as viruses: Once the empire's thin outer membrane was breached, invaders had free rein to pillage the interior.

The inscription on a five-foot-tall altar uncovered in Augsburg by German workers in 1992 is a sort of epitaph for Hadrian's grand idea, noting that on April 24 and 25, A.D. 260, Roman soldiers clashed with barbarians from beyond the German frontier. The Romans prevailed—barely.

Their commander set up an altar to Victory. Reading between the lines reveals a different picture: The barbarians had been raiding deep into Italy for months and were heading home with thousands of Roman captives. "It shows the border is already collapsing," says the German Archaeological Institute's Hüssen.

The empire would never be safe inside its shell again. Pressures on the frontiers finally became too great. Cities across the empire began building their own walls; the emperors scrambled to fight off regular invasions. The costs and chaos were crippling. Within two centuries an empire that once dominated an expanse larger than today's European Union was gone. □

# Home of the Roma

*In a Romanian farm town, once itinerant traders have struck it rich replacing caravans with mansions.*

# Kings

A fantasia of styles, from villa to temple to castle, lines the main street of Buzoiesti, population 5,000. Men are often away on business; women, wealthy or not, stay to cook, clean, and raise the kids.

Six-year-old twins Gelu and Ed. Petrache wait for the parties to start on Easter Sunday. They live in one of the more than a hundred extravagant houses that have gone up since communist rule ended in 1989. The Roma's wealth in Buzescu, on the books and off, comes mostly from trade in silver and other metals.

On Easter Sunday Roma feast on the street, spending big on food, drink, and song. Here a band member accepts money—often it's hundreds of dollars—for calling out the donor's name and playing a request. Local families belong mostly to the Kalderash group, known for making copper stills.

Buzescu's well-to-do have a thing for flamboyant decor. Vandana Ispilante sits with her 13-year-old daughter, Edera, in a bedroom that looks like a honeymoon suite—except for a picture of the Virgin Mary on the headboard. Odds are Edera's closet will never hold head scarves and long flowered skirts, the traditional Romani dress.

*By Tom O'Neill*

*Photographs by Karla Gachet and Ivan Kashinsky*

Hands folded over his prosperous belly, a straw fedora tight on his head like a crown, an old gent named Paraschiv sat back on a bench and surveyed his neighborhood realm. It was quite a sight for rural Romania. Up and down the main road and spilling into dirt side lanes reared improbable mansions. Facades undulated with balconies and pillars. Rooftops looked like party hats, all turrets and towers and domes. Sleek Beemers and Benzes patrolled the streets. Just then, a truck driver with a load of pigs ground down on his brakes to gawk. Paraschiv smiled. This was his hometown; this was Buzescu, showplace for that rarest of Europe's demographics, the wealthy Roma.

Paraschiv doesn't use the word "Roma," the correct, respectful name for his ethnic group, meaning "men" in the Romani language. Instead he and most of his neighbors unselfconsciously refer to themselves as Tsigani, or Gypsies, the old, pejorative name they grew up with, a label

Appearances matter inside the big houses. Casi, 13, wants to look good for husband-to-be Sami, 14, pictured on a closet door. Arranged marriages between children are common among Buzescu's wealthy families. Already Casi lives with Sami's family; they'll officially wed when both reach 17. Parents seem intent on giving children everything they themselves

lacked, from fast cars to the heaps of toys and stuffed animals that keep teenager Madalina Ion company (bottom left). Many grand spaces are used only on holidays and for weddings and funerals. To prepare for Easter, Simona Iancu shines an entrance hall. Doru and Valeria Constantin (below) seldom entertain in their glittery, marble-floored dining room.

In a backyard in the wealthy quarter, traditional village habits maintain a hold. On the day of a baptism, men send off a gift pig to the godparents. Some affluent Roma, especially older ones who grew up traveling in horse-drawn caravans, are uneasy in the mansions and still use outhouses and outdoor kitchens.

Zaharia Bureata greets Easter morning in a tie spun from solid gold thread, its front spelling out his name and the brand of his car, a Hummer. Others in town have copied his style. "People think all Roma are poor and filthy," declared one mansion dweller. "They should see us."

still wielded by many non-Roma in his country, synonymous with beggar, thief, parasite, and other ugly words. In common use since the early 1600s, "Gypsy" derives from "Egyptian," from the supposed origin of the Roma. Linguistic evidence indicates that the Roma came from India.

"I built one of the first mansions, in 1996," Paraschiv said, nodding toward his villa-style home, a fanciful hulk encased in gray and white marble and cornered with balconies. The names of his children, Luigi and Petu, are stenciled atop a tin-sheeted tower. "My sons want to tear down the house and build a different shape; they say it's out of fashion." Paraschiv shrugged. "If my sons want to, then OK."

At two stories, Paraschiv's mansion is modest. Giant five-story palaces ribbed with columns have been multiplying on the southern end of town, the Romani district. Call it the monument style. There's also the corporate HQ look, with curved, mirrored-glass walls; the nobleman's castle, with sherbet-colored battlements and balconies arrayed like opera boxes; and the Swiss chalet, with high peaked roof and gnomes on the porch. It's gaudy, uninhibited architecture, the taste blatantly nouveau riche. In all, about a hundred Romani mansions have sprung up in an otherwise dour farm town of 5,000 people some 50 miles southwest of the capital, Bucharest. About a third of the citizenry is Roma, not all of them rich but enough to make the town a strange, compelling statement of ethnic pride.

"Wealthy Roma" looks like a misprint, a snide joke. For many of the estimated two million Roma in Romania, or about 10 percent of the population, life is poor and nasty, their communities stuck in squalid city slums or in cardboard shanties on the edges of towns. They share this fate with Roma throughout Eastern Europe, where these formerly seminomadic people are a despised underclass, conspicuous for their poverty, lack of education, and stubborn insularity.

To many *gadje,* the Romani term for outsiders, the palatial homes of Buzescu's Roma are a thumb in the eye, a flaunting of undeserved

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*Tom O'Neill is a staff writer. Karla Gachet and Ivan Kashinsky are a married couple based in Quito, Ecuador. Kashinsky photographed Bolivian female wrestlers for our September 2008 issue.*

wealth. The Romani elite, however, seem to care less about impressing outsiders. Townspeople make it clear they don't want strangers stopping to ask questions and take pictures. *Pleaca, pleaca,* go away, go away, children would yell at me. Adults glowered or turned their backs when I approached. "These places are not for you," Roma sociologist Gelu Duminica told me, meaning anyone not Roma. The mansions are built for local eyes only, Duminica said, a way to strut wealth and status inside the Roma community.

So where does the wealth come from? The local Roma simply say, "Metal trading." The Buzescu Roma are mostly Kalderash—"coppersmith" in Romani—a group traditionally associated with metalworking. As recently as the early 1990s, Buzescu families still traveled the countryside in horse-drawn caravans, stopping in towns to sell *cazane,* copper stills for making fruit brandy. It was a lucrative business for the best craftsmen, like Paraschiv, with a cazane selling for hundreds of dollars. Communist authorities, however, kept a tight watch on Romani activities, and the richest families kept a low profile.

When Romania's communist regime fell in 1989, the entrepreneurial instinct of the Kalderash was unleashed. Cazane makers and their sons spread across Romania and the rest of Eastern Europe, stripping derelict factories, sometimes illegally, of silver, copper, aluminum, steel, and other valuable scrap. By playing the commodity market, some Buzescu Roma reaped hefty profits. Marin Nicolae, a former cazane maker, says: "After the revolution, even a stupid person could build five villas buying and selling metal."

For a week I walked up and down the streets of Buzescu, trying to talk my way into mansions. Photographers Karla Gachet and Ivan Kashinsky had paved the way, living two months on and off in the Romani quarter, gaining access to a number of homes only after strenuous persistence. Holding up photos Karla and Ivan had taken of people inside the big houses, I stood at front gates, appealing to the owners' curiosity and vanity. Sometimes it worked.

Front doors would open to gleaming expanses of marble, ceilings hung with chandeliers, and, like the main prop of a stage set, a grand *Gone With the Wind* staircase leading to bedrooms heaped with toys. Yet most rooms looked totally unlived in. In mansions with a dozen rooms or more, often the only occupants were grandparents and a few young children, and they mostly stayed in back rooms and ate in the kitchen. The parents and older sons were off doing business, usually returning for holidays, baptisms, and funerals. The mansions had been built largely as showrooms to be filled with pride and awe.

Another surprise was that behind the showy facades, time-encrusted customs remained in force. At Victor Filisan's house, where he offered me the local drink of Jack Daniel's and Red Bull, I asked to use the toilet. He showed me not to the Jacuzzi-equipped bathroom inside but to an outhouse at the back of the lot, the same one he and his wife use. For reasons of ritual purity, many Roma, especially older ones, do not cook and use the toilet under the same roof. In other houses, I saw teenage wives serving meals to teenage husbands. Arranged matches of children as young as 13 remain common among the town's wealthy families.

The community's itinerant past never seemed that far away either. It was a restless town. Families were constantly leaving, heading off to Spain, France, Bucharest. Old men on corners reminisced about their traveling days, nostalgic for the variety and adventure. They also gossiped about shifting fortunes, blaming a roulette wheel operated by gadje for bankrupting households. On every street people were building new houses or tearing down old ones to erect bigger, bolder mansions, like what Paraschiv's sons had in mind. Nothing seemed permanent except family ties.

"We are the most civilized Gypsies in Romania," a man named Florin bragged to me. "If we see something beautiful, we want something even more beautiful." When I repeated this to an elderly widow, Rada, who had once lived in a mansion but is now ending her days in a small musty house with chickens running in and out the kitchen door, she looked at me, foolish *gadjo,* and said, "No matter how high you build up, everyone ends up in the grave." □

Beyond Buzescu's mansion district, a kitchen belonging to a hard-pressed Romani family serves as a dance hall for Iasmina Iancu, six, twirling for her grandfather Ion, who raises her. Iasmina's mother works in Spain. Many households contain only old and young, the rest scattered across Europe to earn money.

NATIONAL GEOGRAPHIC ON TV

## Alien Deep

Robert Ballard, the man who discovered the *Titanic*, knows a thing or two about the world's oceans. Join him and a team of scientists this month on the National Geographic Channel as they get to the bottom of some deep-sea mysteries. Among their goals: Find out why some marine organisms (collected near Panama by bioengineer Kakani Katija, left) may beat the wind when it comes to ocean-churning power.

MAP

**SOUTHEAST ASIA** Take a closer look at Southeast Asia with National Geographic's new wall map. This detailed map shows current political boundaries, cultural sites, and more. Get it at *shopng.com* ($12.99).

BOOK

**WOMEN'S HEALTH** From the proper dose of omega-3 fatty acids to the value of humor, Tieraona Low Dog takes a holistic approach to wellness. Her new guide combines personal stories, traditional practices, and medical science. Available in stores September 4 ($26).

LECTURE

**AFRICAN CEREMONIES** Photographers Carol Beckwith and Angela Fisher have been traveling to Africa for 30 years. Their new book, *Painted Bodies*, features body adornment from across the continent, including this Maasai warrior's ochered face. For speaking dates in Los Angeles, Chicago, and Arizona go to *nglive.org*.

EXHIBIT

**1001 INVENTIONS** This exhibit highlights the scientific innovations of Muslim civilization from the 7th to 17th centuries. At the National Geographic Museum until February 3. Visit *ngmuseum.org/1001*.

Free Download of the Month

**Depedro** *Complete Depedro*

**The music of Depedro—the solo project of Spanish singer and songwriter Jairo Zavala—is rooted in the sounds of Spain and Latin America. Comprising ■ sides, live tracks, and remixes, Zavala's new EP, *Complete Depedro*, seduces from the moment you hit play. Download a free song at *natgeomusic.net/free*.**



PHOTOS: NATIONAL GEOGRAPHIC TELEVISION (DIVER), CAROL BECKWITH AND ANGELA FISHER (WARRIOR)

# U.S. GOV'T GOLD AT-COST

**TODAY - The U.S. Money Reserve has scheduled the final release of U.S. Gov't-Issued $5 Gold Coins previously held at the U.S. Mint at West Point. These Gov't-Issued Gold Coins are being released on a first-come, first-served basis for the incredible markup free price of only $168.25 per coin. Please be advised: our at-cost U.S. Gov't Gold inventory will be available at this special price while supplies last or for up to 30 days. Do not delay. Call a Sr. Gold Specialist today.**

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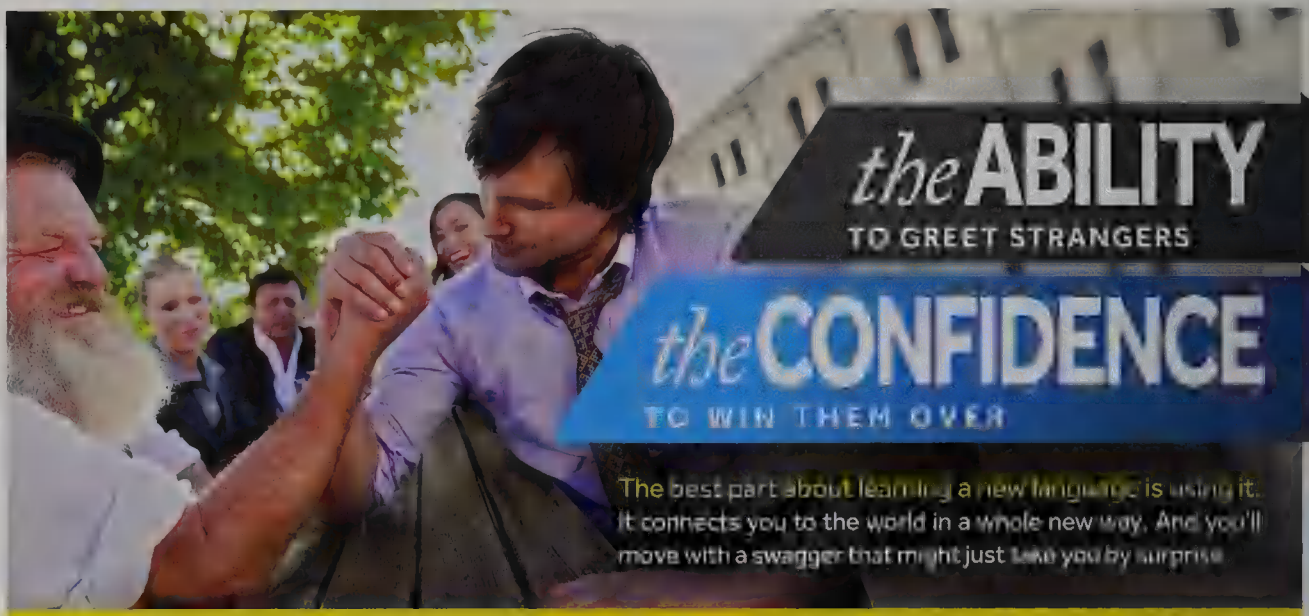
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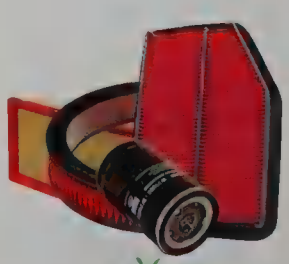
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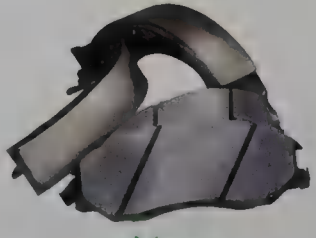
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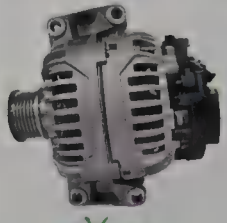
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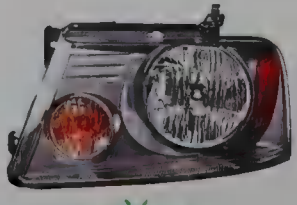
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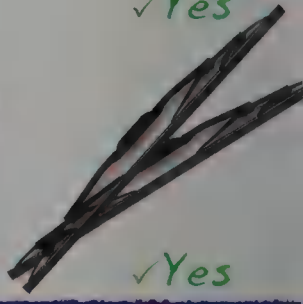
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NATIONAL GEOGRAPHIC

# Give An *Inspiring* Gift

Pat Minnick included National Geographic in her financial plans.

In 2007 Pat Minnick, a professional artist, decided to establish a charitable gift annuity to support National Geographic.

"I feel good knowing that National Geographic is doing so much to protect endangered wildlife," says Pat. "The environmental problems we face are vast, but by joining with National Geographic and their history of remarkable accomplishments, I know we can pass on a more beautiful world."

Pat now receives a guaranteed life income and is a direct part of the Society's efforts to inspire people to care about the planet.

For more information about a charitable gift annuity or other ways to include National Geographic in your estate plans, please see below.

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Photo: Ted Lepold

# Brothers, Now and Then

Luck and a storekeeper's camera phone were in play when Robb Kendrick made a new picture of two Mennonite brothers he had photographed 29 years earlier. Looking to capture the toll of last year's severe drought in his home state of Texas, he remembered Seminole, an agricultural community he had visited as a junior in college. "I like photographing people with hard jobs," Kendrick says. Gerhard and Peter Neustaeter, both cotton farmers, lost their entire crop in 2011. Reunited, the trio caught up on life. *—Luna Shyr*

BEHIND THE LENS

## How did the brothers cope with the 2011 Texas drought?

**RK:** Gerhard [at left in both photos] and Peter are like many farmers—they have a lot of faith that next year's going to be better. If you're a farmer, you have to constantly be optimistic. Last year was rough, but crop insurance helped, plus that farmers' ability to put so much hard work into something they're not in control of. Also Mennonites are very pragmatic people. They don't cry over spilled milk.

**How did you find them again nearly 30 years later?**

It was a real shot in the dark, but I went into a Mennonite farm-supply store with the original photo I took of them. The store owner took a picture of the picture with his phone and emailed it to the community. Within 15 minutes one of the brothers showed up.

**And you went back to their town because...**

For this assignment I wanted to visit places I had a connection to. In college I passed through Seminole on my way home to visit my folks. Gerhard and Peter were 13 and 12 years old back then. We had a good time catching up—Peter said we should do it again in another 29 years.

# A Class Action Settlement About Chinese Drywall May Affect You

A Settlement has been reached in a class action lawsuit involving drywall imported to the U.S. from China. The lawsuit claims that this Chinese Drywall caused property damage and personal injuries.

The companies being sued are distributors, suppliers, builders, developers, and installers who were associated with Chinese Drywall. Some of these companies ("Participating Defendants") and some of their insurance companies ("Participating Insurers") have agreed to a Settlement. The Participating Defendants and the Participating Insurers deny they did anything wrong.

## Who's Included?

You are likely included in the Class if you have any claim for property damage or personal injuries related to Chinese Drywall installed anywhere in the U.S., except for in Virginia. For the specific legal definition of the Class, please visit the website or call the phone number below.

## What Can You Get?

Under the Settlement, Participating Defendants and Participating Insurers will contribute $80 million into a Settlement Fund. At a later date, after other Chinese Drywall Settlements are resolved, the Court will approve a plan to distribute the Settlement Fund to Class Members. At that time, Class Members may receive payments for their damages. You can register at the website below to be updated if a claims process is available.

## Your Other Rights

If you do nothing, you remain in the Class and you may be eligible to receive Settlement benefits. You will be bound by all the Court's decisions. If you do not want to be legally bound by the Settlement, you must exclude yourself from the Settlement. The deadline to exclude yourself is **September 28, 2012**. If you do not exclude yourself you will not be able to sue the Participating Defendants or the Participating Insurers for any claim relating to the lawsuit. If you stay in the Settlement, you may object to all or part of it by **September 28, 2012**. The Court will hold a hearing on **November 13, 2012** to consider whether to approve the Settlement. The Court has appointed attorneys to represent the Class. If you wish, you or your own attorney may ask to appear and speak at the hearing at your own cost.

This notice is only a summary. Use the information below to get detailed information, and to register to receive future notifications about this Settlement and related Chinese Drywall Settlements.

---

**Call: 1-877-418-8087**
**or Visit www.ChineseDrywallClass.com**

# Insides Out

Sitting in a Nome, Alaska, photo studio in the early 1900s, an Eskimo man models a parka fashioned of walrus intestine. Impermeable when wet and easy to come by for the sea-focused people, the material was prepared by air curing, then sliced and sewn with a waterproof stitch—the same as used for watercraft, including the umiak (canoe) he's holding. The jacket's extra material at the hem functioned as a spray skirt when he was at sea.

Other innards also had uses: Bladders became water bags, guts got sewn together as sod-house windows, and stomachs could be stretched for tambourine drums. *—Johnna Rizzo*

**Flashback Archive** Find all the photos at **ngm.com.**

PHOTO: BEVERLY B. DOBBS, NATIONAL GEOGRAPHIC STOCK

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INVESTIGATIVE REPORT

# Blood Ivory

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# NATIONAL GEOGRAPHIC

*Some plant leaves have become specialists in deadly tricks.*
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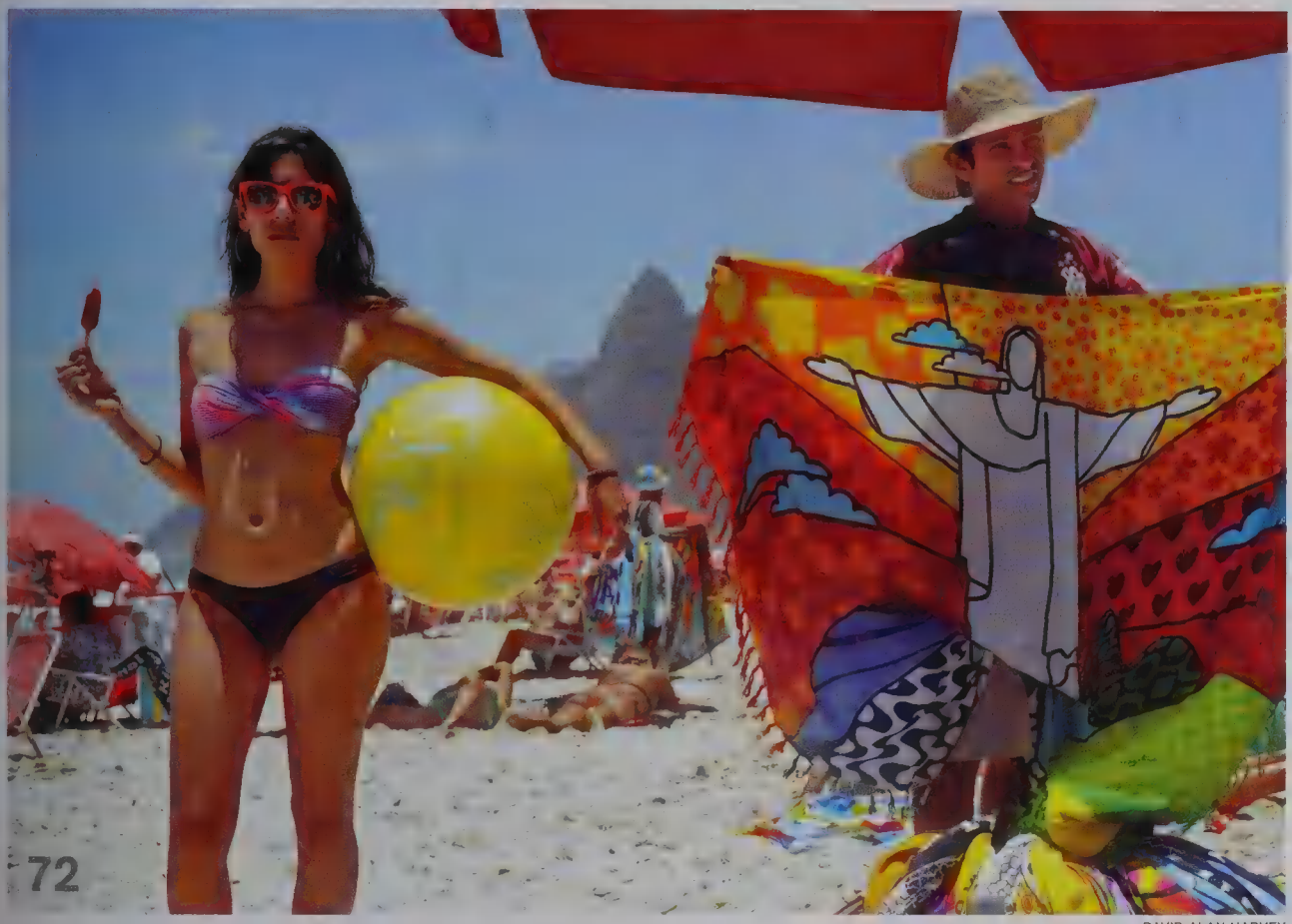

DAVID ALAN HARVEY

You can buy nearly anything from a vendor along the 50-plus miles of Rio beaches: Popsicle, ball, cover-up emblazoned with the city's statue of Christ the Redeemer.

## *October 2012*


**33 Ivory Worship**
A *National Geographic* investigation reveals how the religious art market fuels ivory smuggling.
*By Bryan Christy Photographs by Brent Stirton*

**62 The Glory of Leaves**
Sleek or prickly, waxy or spiny, pure green or silvery white…why do they look the way they do?
*By Rob Dunn*

**72 A New Face for Rio**
With the Olympics coming in 2016, the city is spending millions to fix up its hillside slums.
*By Antonio Regalado Photos by David Alan Harvey*

**92 Amazing Mesoamerican Reef**
In this world, mangrove forests, sea grass beds, and coral reefs strike a delicate balance.
*By Kenneth Brower Photographs by Brian Skerry*

**114 The Sky Caves of Nepal**
Explorers scramble up cliffs to find out who created these ancient dwellings.
*By Michael Finkel Photographs by Cory Richards*

**136 My Neighbor, Mr. Badger**
The people moved away from their cottages in a rural Finnish town. And the animals moved in.
*By Carolyn Butler Photographs by Kai Fagerström*

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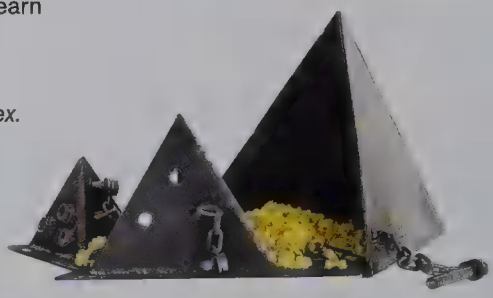
**Baboons Recognize Words**
But it is not yet clear if they can learn the meaning behind "banana."

**Feathered Dino**
It weighed a ton. It was kin to *T. rex*. And it had a coat of down.

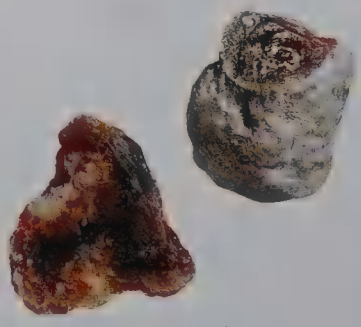
**Elephant Toys ▸**
If a pachyderm twists the bolts on the pyramids at right, it gets a treat.


**Chinese Driving Test**
Among the questions: How should you jump from an overturning car?

**Eau de Whale ▸**
Ambergris emerges from a sperm whale's belly, enters high-end perfumes.

**Birth of Amasia**
In 100 million years Earth's shifting landmasses may form a new continent.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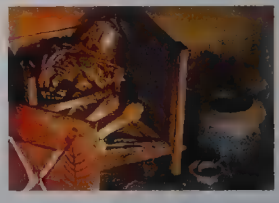
145 The Moment
Flashback


## DIGITAL EDITIONS

**Ivory**
Video
*See video from Bryan Christy's investigation.*

**Mesoamerican Reef**
Video
*Swim amid a school of spawning snappers.*



**Mustang Caves**
Video + 3-D Animation
*Explore a model of a cliffside burial cave.*

**On the Cover** The ivory market reaches from Africa to Asia. In Kenya (left) a ranger removes tusks from an elephant killed illegally; the aim is to keep the ivory off the black market. In China (right) a carver works with ivory.
*Inset photos by Brent Stirton; background photo by Michael Nichols*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# Blood Ivory

In an exclusive luxury-goods shop in Beijing, I watch a Chinese couple admire an elaborate ivory carving selling for hundreds of thousands of dollars. They see the exquisitely made object as an affirmation of personal wealth. I see carnage and death. I can smell the death too. About 15 years ago, on assignment in Zimbabwe, I photographed a group of rotting African elephant carcasses—the tragic remains of a family massacred for ivory.

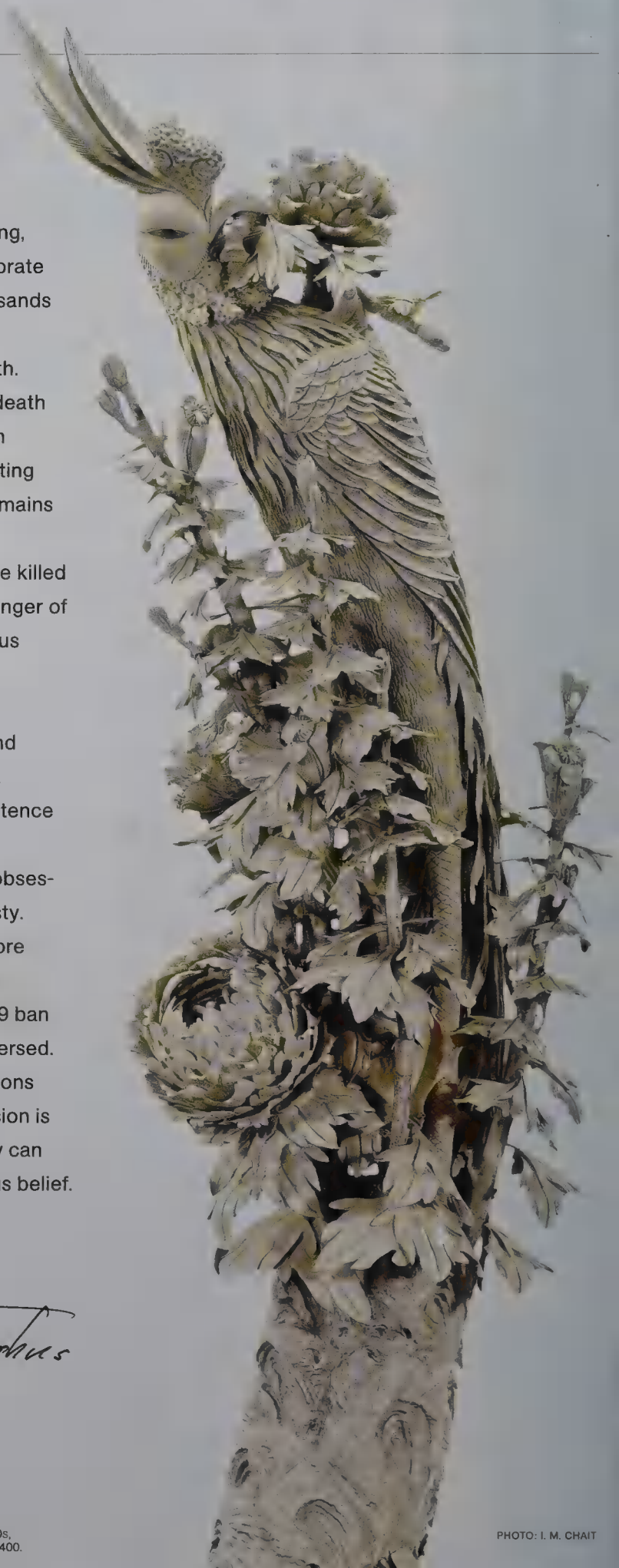
Every year at least 25,000 elephants are killed by poachers for their tusks to feed the hunger of ivory collectors and the market for religious objects. The slaughter is massive and accelerating. The very existence of these magnificent beasts is at risk.

**The slaughter is massive and accelerating.**

The fate of elephants has become an obsession for investigative reporter Bryan Christy. He has been digging into this story for more than two years. His findings are shocking. Elephant poaching declined after the 1989 ban on ivory sales, but that trend has now reversed.

As Bryan explains in this issue, the reasons for this reversal are many, but the conclusion is singular: The killing must stop. Blood ivory can no longer be a badge of wealth or religious belief.

The cost is too high.





THIS 44-INCH-LONG CHINESE PHOENIX, CARVED IN THE 1920s, IS ONE OF A PAIR OF TUSKS THAT SOLD IN THE U.S. FOR $24,400.

PHOTO: I. M. CHAIT

**Greater Prairie-chicken** *(Tympanuchus cupido)*
**Size:** Head and body length, 40 - 45 cm (16 - 18.8 inches); wingspan, 56 - 66 cm (22 - 26 inches) **Weight:** Males, 0.9 - 1.2 kg (2 - 2.6 lbs); females, 0.75 - 0.95 kg (1.7 - 2.1 lbs) **Habitat:** Primarily mixed and tall-grass prairie **Surviving number:** Estimated at 460,000 mature individuals

*Photographed by Wendy Shattil and Bob Rozinski*

# WILDLIFE AS CANON SEES IT

Room to boom. Male greater prairie-chickens establish booming grounds during breeding season, where they announce their prowess through vocalizations produced via their bright orange neck sacs. To impress females, they also strut and "flutter jump," flapping their wings and jumping with a whoop, cackle or whine. Females, who usually visit more than one booming ground prior to mating, lay clutches of about a dozen eggs in bowl-shaped nests lined with dry grass and feathers. But as their native prairies are converted to crop land, they are feeling the squeeze. Populations have fallen by 90% in the last 40 years.

As we see it, we can help make the world a better place. Raising awareness of endangered species is just one of the ways we at Canon are taking action—for the good of the planet we call home. Visit **canon.com/environment** to learn more.

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## Solar Storms

Those researching space weather seem to have neglected to study geomagnetic reversals, which are the basis of seafloor spreading. One would hope that meteorologists, astronomers, and geologists would utilize information from other sciences. It would seem to be significant that we have evidence that solar storms have, over geologic time, reversed Earth's magnetic field. The severity of electromagnetic disruption that could be attendant with such a future solar storm would be staggering.

**MICHAEL H. FRIMPTER**
**USGS Geologist, Retired**
**Naples, Florida**

I was wondering if there is any way to organize a graceful shutdown of the electrical grid in a large area if we had two days to prepare. I'm doubtful that humans could get past the political, bureaucratic, and security concerns, and I'm sure the crazies would be out in force if we could accomplish this. But how much money, effort, and tragedy could we save if we thought that far ahead?

**DANE WARNER**
**Glendora, California**

I have a friend who for some reason monitors Russian websites. For the past few months she's been telling all of her friends about how huge solar storms can wipe out electricity and shut down entire cities. We just ignored her, thinking she was just being paranoid. And then I got this issue. Thanks to your magazine's coverage, she now has something to hold over us.

**BIANCA WILHELM**
**Windermere, Florida**

Your "Sun Struck" article, and other publications, declare it a mystery why the corona is so much hotter than the sun's surface—an anomaly that any heat source object should be hotter at a greater radius, rather than cooler. To me, the riddle has been answered. Solar flares and their magnetic reconnection events are a nuclear fusion process known as the CNO cycle, an early hypothesis of [physicist] Hans Bethe's for the sun's core yet never imagined at the sun's surface.

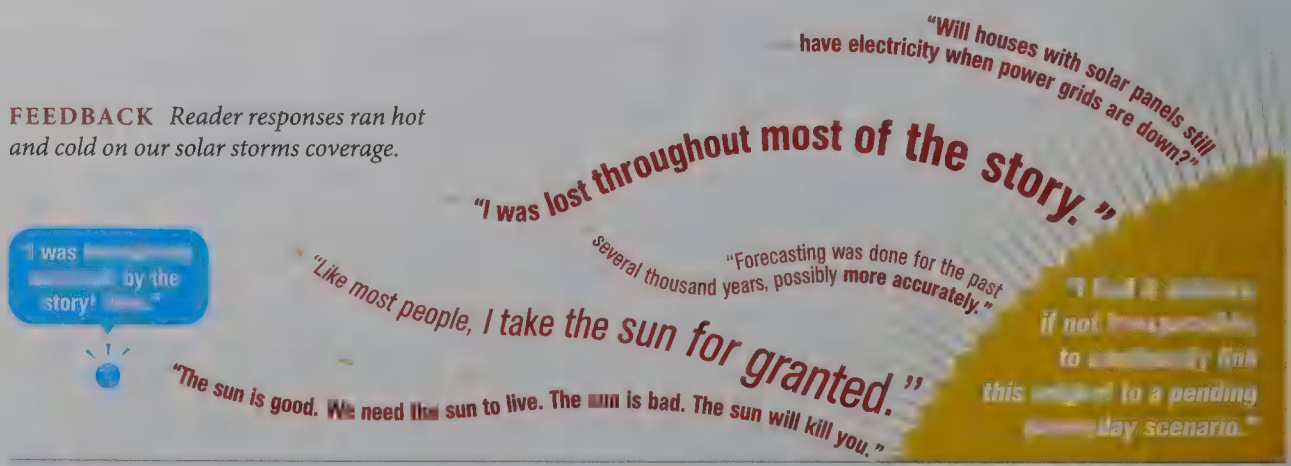
**NOEL EBERZ**
**Naalehu, Hawaii**

## Hong Kong

Your article reminded me of my five-day visit in 1957. When our plane landed, we were surrounded by groups of tailors—mine were three supposed brothers, John, Robert, and Patrick. The material was picked out on day one, sewn and fitted on day two, boxed on day three, and fell apart when I got back to Okinawa on day six.

**BERNARD A. YABLIN**
**Rochester, New York**

**FEEDBACK** *Reader responses ran hot and cold on our solar storms coverage.*


"Will houses with solar panels still have electricity when power grids are down?"
"I was lost throughout most of the story."
"Forecasting was done for the past several thousand years, possibly more accurately."
"Like most people, I take the sun for granted."
"The sun is good. We need the sun to live. The sun is bad. The sun will kill you."

**EMAIL** ngsforum@ngm.com **TWITTER** @NatGeoMag **WRITE** National Geographic Magazine, PO Box 98199, Washington, DC 20090-8199. Include name, address, and daytime telephone. Letters may be edited for clarity and length.



GRAPHIC: JUAN VELASCO, NGM STAFF

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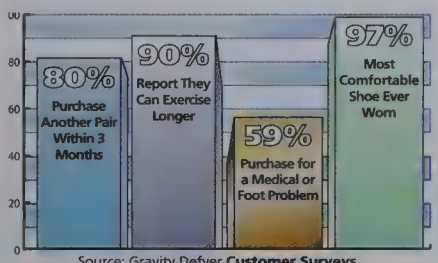


Source: Gravity Defyer **Customer Surveys**

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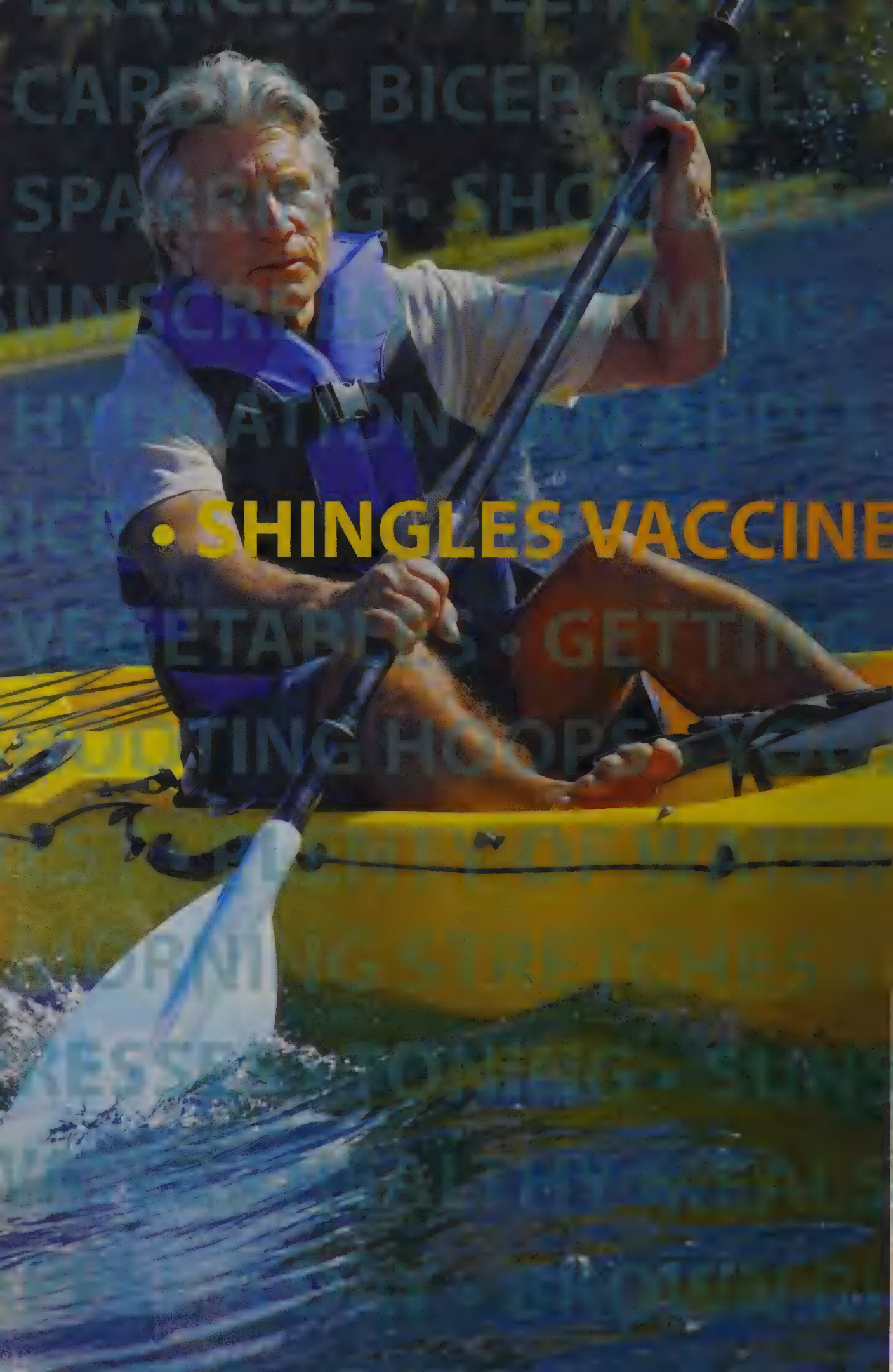
• SHINGLES VACCINE

# XPLORE. EXERT.
# S YOU GET OLDER, REALLY GREAT.
# UT DON'T FORGET TO VACCINATE.

## ow's the time to help prevent Shingles with ZOSTAVAX® (Zoster Vaccine Live).

STAVAX is a vaccine that helps prevent Shingles in adults 50 years of age older. Shingles is caused by the same virus that causes chickenpox. The us stays in your body and can resurface at any time as Shingles—a painful, stering rash. And no matter how healthy you feel, your risk increases as u get older.

e sooner you get vaccinated with ZOSTAVAX, the better your chances of otecting yourself from Shingles. In fact, the ACIP* of the CDC (Centers for Disease Control and Prevention) commends that appropriate adults 60 years of age and older get vaccinated to help prevent Shingles.

## lk to your health care professional to see if ZOSTAVAX is right for you.

STAVAX is given as a single shot. ZOSTAVAX cannot be used to treat Shingles, or the nerve pain that may llow Shingles, once you have it. For more information, visit ZOSTAVAX.com or call 1-877-9 SHINGLES.

## BOUT ZOSTAVAX

STAVAX is a vaccine that is used for adults 50 years of age or older to prevent Shingles (also known as zoster).

## nportant Safety Information

OSTAVAX does not protect everyone, so some people who get the vaccine may still get Shingles.

ou should not get ZOSTAVAX if you are allergic to any of its ingredients, including gelatin or neomycin, ave a weakened immune system, take high doses of steroids, or are pregnant or plan to become regnant. You should not get ZOSTAVAX to prevent chickenpox.

alk to your health care professional if you plan to get ZOSTAVAX at the same time as PNEUMOVAX®23 Pneumococcal Vaccine Polyvalent) because it may be better to get these vaccines at least 4 weeks apart.

ossible side effects include redness, pain, itching, swelling, hard lump, warmth, or bruising at the njection site, as well as headache.

OSTAVAX contains a weakened chickenpox virus. Tell your health care professional if you will be in close ontact with newborn infants, someone who may be pregnant and has not had chickenpox or been accinated against chickenpox, or someone who has problems with their immune system. Your health are professional can tell you what situations you may need to avoid.

u are encouraged to report negative side effects of prescription drugs to the FDA. sit www.fda.gov/medwatch or call 1-800-FDA-1088.

ease read the Patient Information on the adjacent page for more detailed information.

IP=Advisory Committee on Immunization Practices

## efore you get Shingles, get vaccinated.

ZOSTAVAX®
Zoster Vaccine Live

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CC-1016603-0025 05/12

# Patient Information about ZOSTAVAX® (pronounced "ZOS tah vax") Generic name: Zoster Vaccine Live



You should read this summary of information about ZOSTAVAX before you are vaccinated. If you have any questions about ZOSTAVAX after reading this page, you should ask your health care provider. This information does not take the place of talking about ZOSTAVAX with your doctor, nurse, or other health care provider. Only your health care provider can decide if ZOSTAVAX is right for you.

**What is ZOSTAVAX and how does it work?**

ZOSTAVAX is a vaccine that is used for adults 50 years of age or older to prevent shingles (also known as zoster).

ZOSTAVAX contains a weakened chickenpox virus (varicella-zoster virus).

ZOSTAVAX works by helping your immune system protect you from getting shingles.

If you do get shingles even though you have been vaccinated, ZOSTAVAX may help prevent the nerve pain that can follow shingles in some people. ZOSTAVAX does not protect everyone, so some people who get the vaccine may still get shingles.

ZOSTAVAX cannot be used to treat shingles, or the nerve pain that may follow shingles, once you have it.

**What do I need to know about shingles and the virus that causes it?**

Shingles is caused by the same virus that causes chickenpox. Once you have had chickenpox, the virus can stay in your nervous system for many years. For reasons that are not fully understood, the virus may become active again and give you shingles. Age and problems with the immune system may increase your chances of getting shingles.

Shingles is a rash that is usually on one side of the body. The rash begins as a cluster of small red spots that often blister. The rash can be painful. Shingles rashes usually last up to 30 days and, for most people, the pain associated with the rash lessens as it heals.

**Who should not get ZOSTAVAX?**

You should not get ZOSTAVAX if you:

- are allergic to any of its ingredients.
- are allergic to gelatin or neomycin.
- have a weakened immune system (for example, an immune deficiency, leukemia, lymphoma, or HIV/AIDS).
- take high doses of steroids by injection or by mouth.
- are pregnant or plan to get pregnant.

You should not get ZOSTAVAX to prevent chickenpox.

Children should not get ZOSTAVAX.

**How is ZOSTAVAX given?**

ZOSTAVAX is given as a single dose by injection under the skin.

**What should I tell my health care provider before I get ZOSTAVAX?**

You should tell your health care provider if you:

- have or have had any medical problems.
- take any medicines, including non-prescription medicines, and dietary supplements.
- have any allergies, including allergies to neomycin or gelatin.
- had an allergic reaction to another vaccine.
- are pregnant or plan to become pregnant.
- are breast-feeding.

Tell your health care provider if you expect to be in close contact (including household contact) with newborn infants, someone who may be pregnant and has not had chickenpox or been vaccinated against chickenpox, or someone who has problems with their immune system. Your health care provider can tell you what situations you may need to avoid.

**Can I get ZOSTAVAX with other vaccines?**

Talk to your health care provider if you plan to get ZOSTAVAX at the same time as the flu vaccine.

Talk to your health care provider if you plan to get ZOSTAVAX at the same time as PNEUMOVAX®23 (Pneumococcal Vaccine Polyvalent) because it may be better to get these vaccines at least 4 weeks apart.

**What are the possible side effects of ZOSTAVAX?**

The most common side effects that people in the clinical studies reported after receiving the vaccine include:

- redness, pain, itching, swelling, hard lump, warmth, or bruising where the shot was given.
- headache

The following additional side effects have been reported with ZOSTAVAX:

- allergic reactions, which may be serious and may include difficulty in breathing or swallowing. If you have an allergic reaction, call your doctor right away.
- chickenpox
- fever
- hives at the injection site
- joint pain
- muscle pain
- nausea
- rash
- rash at the injection site
- swollen glands near the injection site (that may last a few days to a few weeks)

Tell your health care provider if you have any new or unusual symptoms after you receive ZOSTAVAX. For a complete list of side effects, ask your health care provider.

Call 1-800-986-8999 to report any exposure to ZOSTAVAX during pregnancy.

**What are the ingredients of ZOSTAVAX?**

Active Ingredient: a weakened form of the varicella-zoster virus.

Inactive Ingredients: sucrose, hydrolyzed porcine gelatin, sodium chloride, monosodium L-glutamate, sodium phosphate dibasic, potassium phosphate monobasic, potassium chloride.

This page summarizes important information about ZOSTAVAX. If you would like more information, talk to your health care provider or visit the website at www.ZOSTAVAX.com or call 1-800-622-4477.

**Rx only**

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NATIONAL GEOGRAPHIC

# Give An *Inspiring* Gift

Pat Minnick included National Geographic in her financial plans.

In 2007 Pat Minnick, a professional artist, decided to establish a charitable gift annuity to support National Geographic.

"I feel good knowing that National Geographic is doing so much to protect endangered wildlife," says Pat. "The environmental problems we face are vast, but by joining with National Geographic and their history of remarkable accomplishments, I know we can pass on a more beautiful world."

Pat now receives a guaranteed life income and is a direct part of the Society's efforts to inspire people to care about the planet.

For more information about a charitable gift annuity or other ways to include National Geographic in your estate plans, please see below.

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## CONTACT US:

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Web: www.nationalgeographic.org/donate

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☐ I have already included National Geographic in my will.

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Washington, D.C. 20036-4688

Photo: Mel Lipeda

*Inspiring people to care about the planet*

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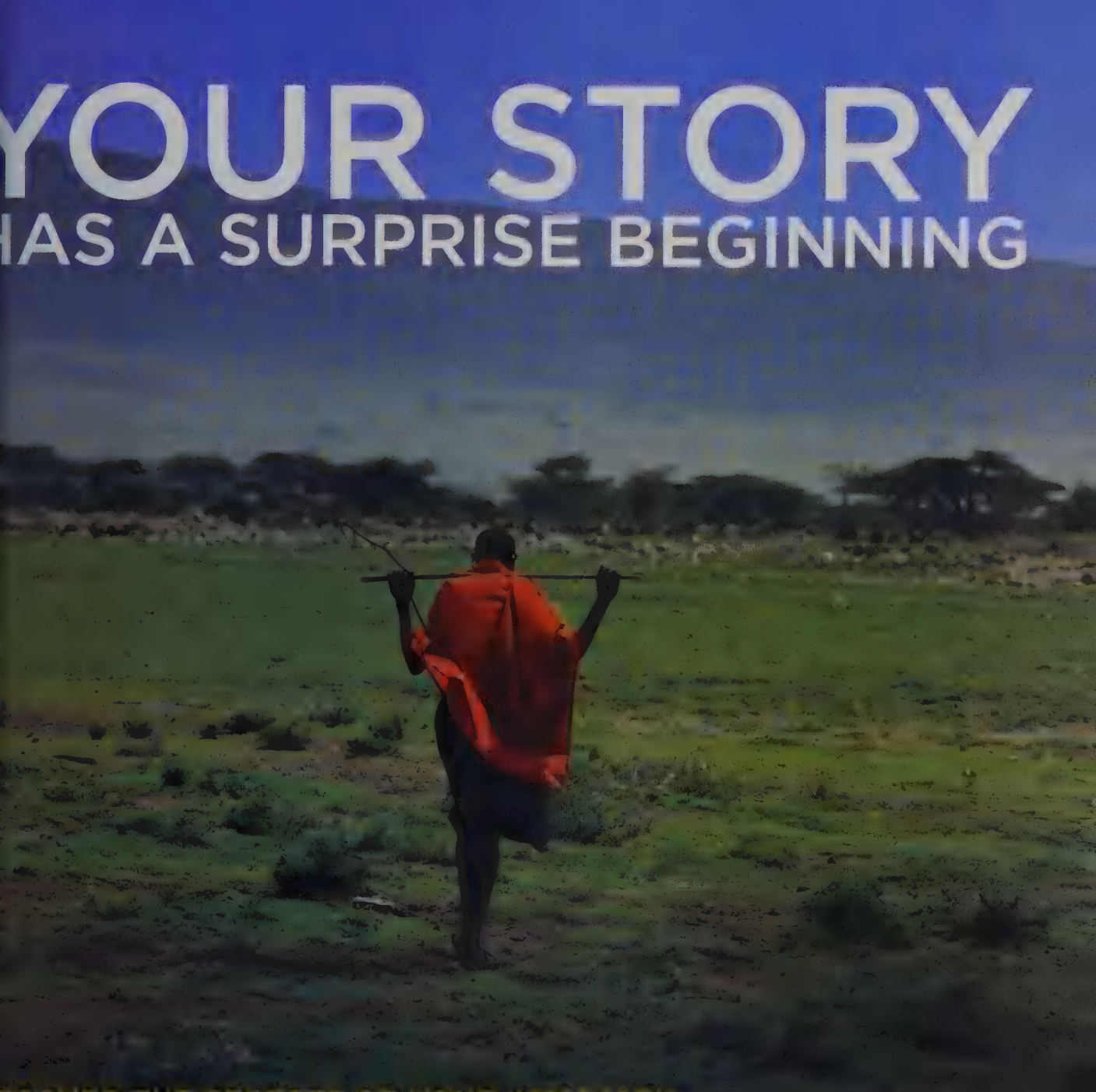

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*Sarah McNair-Landry*

**MISSION** *To inspire youth to get outdoors and get active, promoting a healthy lifestyle and a love of nature*

**LOCATION**
*Arctic Ocean, Canada*

# Across the Ice

Something woke me at four in the morning, and it's a good thing it did. A polar bear was about to attack the tent right above my head. As claws started to rip the fabric, I kicked and screamed. That woke my brother, Eric, who charged after the bear with a camp shovel. In the chaos I managed to find our shotgun, fire it in the air a couple times, and scare off the bear for good.

Eric and I were attempting the first kite-skiing traverse of the frozen Northwest Passage. We had set off in March 2011 from Tuktoyaktuk, in Canada's Northwest Territories, and hoped to end on Baffin Island, Nunavut, where we had grown up. Our parents are adventure guides, so we spent weekends on dogsleds learning to have fun in the cold. As teenagers we took up kite skiing—catching the strong polar winds with a kite to pull us over the ice and snow. Now we're showing how it can open new routes by moving expeditions quickly over long distances.

On this trip the native Inuit tracked our progress through the radio interviews we did along the way. When we got to a town, they were always waiting for us. After 85 days and 2,050 miles, we pulled into Pond Inlet, on Baffin Island, where people welcomed us with a square dance. There was only one thing to do. We took off our skis and joined in. *—Sarah McNair-Landry*

McNair-Landry tows supply sleds on foot after dangerous winds forced her off her skis.



PHOTOS: ERIC MCNAIR-LANDRY; ABBY FENTON, WILL STEGER FOUNDATION (TOP)

For patients 12 years and older whose asthma is not well controlled on a long-term asthma medicine or whose disease severity warrants

## IF YOU THINK ASTHMA 'COMES AND GOES'

# THINK AGAIN.

IT'S MISUNDERSTOOD. ASTHMA DOESN'T COME AND GO. Inflammation, the root cause of asthma is always there, making your lungs more vulnerable to triggers. So, while it's important to avoid triggers, it's also important to treat this inflammation. SYMBICORT helps reduce the underlying inflammation. SYMBICORT helps keep airways open and improve lung function for better breathing all day and night.* SYMBICORT does not replace a rescue inhaler for sudden symptoms. Once your asthma is well controlled, your doctor will decide if you can stop taking SYMBICORT without loss of control and may prescribe a long-term asthma control medicine such as an inhaled corticosteroid.

* When taken twice daily.

**Ask your doctor about SYMBICORT.**

## IMPORTANT INFORMATION ABOUT SYMBICORT

**Important Safety Information About SYMBICORT for Asthma**

**SYMBICORT contains formoterol, a long-acting beta$_2$-adrenergic agonist (LABA). LABA medicines such as formoterol increase the risk of death from asthma problems. It is not known whether budesonide, the other medicine in SYMBICORT, reduces the risk of death from asthma problems seen with formoterol. SYMBICORT should be used only if your health care provider decides that your asthma is not well controlled with a long-term asthma control medicine, such as an inhaled corticosteroid, or that your asthma is severe enough to begin treatment with SYMBICORT.**

If you are taking SYMBICORT, see your health care provider if your asthma does not improve or gets worse. It is important that your health care provider assess your asthma control on a regular basis. Your doctor will decide if it is possible for you to stop taking SYMBICORT and start taking a long-term asthma control medicine without loss of asthma control. Children and adolescents who take LABA medicines may have an increased risk of being hospitalized for asthma problems.

SYMBICORT does not replace rescue inhalers for sudden asthma symptoms.

Be sure to tell your health care provider about all your health conditions, including heart conditions or high blood pressure, and all medicines you may be taking. Some patients taking SYMBICORT may experience increased blood pressure, heart rate, or change in heart rhythm.

Do not use SYMBICORT more often than prescribed. While taking SYMBICORT, never use another medicine containing a LABA for any reason. Ask your health care provider or pharmacist if any of your other medicines are LABA medicines, as using too much LABA may cause chest pain, increase in blood pressure, fast and irregular heartbeat, headache, tremor, and nervousness.

Patients taking SYMBICORT should call their health care provider or get emergency medical care:

- if you experience serious allergic reactions including rash, hives, swelling of the face, mouth and tongue, and breathing problems.
- if you think you are exposed to infections such as chicken pox or measles, or if you have any signs of infection. You may have a higher chance of infection.
- if you experience an increase in wheezing right after taking SYMBICORT, eye problems including glaucoma and cataracts, decreases in bone mineral density, swelling of blood vessels (signs include a feeling of pins and needles or numbness of arms or legs, flu like symptoms, rash, pain and swelling of the sinuses), decrease in blood potassium and increase in blood sugar levels.

If you are switching to SYMBICORT from an oral corticosteroid, follow your health care provider's instructions to avoid serious health risks when you stop using oral corticosteroids. Common side effects include nose and throat irritation, headache, upper respiratory tract infection, sore throat, sinusitis, stomach discomfort, flu, back pain, nasal congestion, vomiting, and thrush in the mouth and throat.

**Approved Uses for SYMBICORT for Asthma**

SYMBICORT is a medicine for the treatment of asthma for people 12 years and older whose doctor has determined that their asthma is not well controlled with a long term asthma control medicine such as an inhaled corticosteroid or whose asthma is severe enough to begin treatment with SYMBICORT. SYMBICORT is not a treatment for sudden asthma symptoms.

**Please see Important Product Information on adjacent page and discuss with your doctor.**

*You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch or call 1-800-FDA-1088.*

**FREE PRESCRIPTION OFFER† Call 1-800-687-3755 or visit MySymbicort.com**

† Subject to eligibility rules. Restrictions apply.

**For more information, call 1-866-SYMBICORT or go to MySymbicort.com**

*If you're without prescription coverage and can't afford your medication, AstraZeneca may be able to help. For more information, please visit www.astrazeneca-us.com*

**Symbicort®**
(budesonide/formoterol fumarate dihydrate)
Inhalation Aerosol

AstraZeneca

# IMPORTANT INFORMATION ABOUT SYMBICORT

Please read this summary carefully and then ask your doctor about SYMBICORT.

**No advertisement can provide all the information needed to determine if a drug is right for you or take the place of careful discussions with your health care provider. Only your health care provider has the training to weigh the risks and benefits of a prescription drug.**

## WHAT IS THE MOST IMPORTANT INFORMATION I SHOULD KNOW ABOUT SYMBICORT?

**People with asthma who take long-acting beta$_2$-agonist (LABA) medicines, such as formoterol (one of the medicines in SYMBICORT), have an increased risk of death from asthma problems. It is not known whether budesonide, the other medicine in SYMBICORT, reduces the risk of death from asthma problems seen with formoterol.**

**SYMBICORT should be used only if your health care provider decides that your asthma is not well controlled with a long-term asthma control medicine, such as an inhaled corticosteroid, or that your asthma is severe enough to begin treatment with SYMBICORT.** Talk with your health care provider about this risk and the benefits of treating your asthma with SYMBICORT.

If you are taking SYMBICORT, see your health care provider if your asthma does not improve or gets worse. It is important that your health care provider assess your asthma control on a regular basis. Your doctor will decide if it is possible for you to stop taking SYMBICORT and start taking a long-term asthma control medicine without loss of asthma control.

Get emergency medical care if:

- breathing problems worsen quickly, and
- you use your rescue inhaler medicine, but it does not relieve your breathing problems.

Children and adolescents who take LABA medicines may be at increased risk of being hospitalized for asthma problems.

## WHAT IS SYMBICORT?

SYMBICORT is an inhaled prescription medicine used for asthma and chronic obstructive pulmonary disease (COPD). It contains two medicines:

- Budesonide (the same medicine found in Pulmicort Flexhaler™, an inhaled corticosteroid). Inhaled corticosteroids help to decrease inflammation in the lungs. Inflammation in the lungs can lead to asthma symptoms
- Formoterol (the same medicine found in Foradil® Aerolizer®). LABA medicines are used in patients with COPD and asthma to help the muscles in the airways of your lungs stay relaxed to prevent asthma symptoms, such as wheezing and shortness of breath. These symptoms can happen when the muscles in the airways tighten. This makes it hard to breathe, which, in severe cases, can cause breathing to stop completely if not treated right away

SYMBICORT is used for asthma and chronic obstructive pulmonary disease as follows:

**Asthma**

SYMBICORT is used to control symptoms of asthma and prevent symptoms such as wheezing in adults and children ages 12 and older.

**Chronic Obstructive Pulmonary Disease**

COPD is a chronic lung disease that includes chronic bronchitis, emphysema, or both. SYMBICORT 160/4.5 mcg is used long term, two times each day, to help improve lung function for better breathing in adults with COPD.

## WHO SHOULD NOT USE SYMBICORT?

Do not use SYMBICORT to treat sudden severe symptoms of asthma or COPD or if you are allergic to any of the ingredients in SYMBICORT.

## WHAT SHOULD I TELL MY HEALTH CARE PROVIDER BEFORE USING SYMBICORT?

Tell your health care provider about all of your health conditions, including if you:

- **have heart problems**
- **have high blood pressure**
- **have seizures**
- **have thyroid problems**
- **have diabetes**
- **have liver problems**
- **have osteoporosis**
- **have an immune system problem**
- **have eye problems such as increased pressure in the eye, glaucoma, or cataracts**
- **are allergic to any medicines**
- **are exposed to chicken pox or measles**
- **are pregnant or planning to become pregnant.** It is not known if SYMBICORT may harm your unborn baby
- **are breast-feeding.** Budesonide, one of the active ingredients in SYMBICORT, passes into breast milk. You and your health care provider should decide if you will take SYMBICORT while breast-feeding

Tell your health care provider about all the medicines you take including prescription and nonprescription medicines, vitamins, and herbal supplements. SYMBICORT and certain other medicines may interact with each other and can cause serious side effects. Know all the medicines you take. Keep a list and show it to your health care provider and pharmacist each time you get a new medicine.

## HOW DO I USE SYMBICORT?

Do not use SYMBICORT unless your health care provider has taught you and you understand everything. Ask your health care provider or pharmacist if you have any questions.

Use SYMBICORT exactly as prescribed. **Do not use SYMBICORT more often than prescribed.** SYMBICORT comes in two strengths for asthma: 80/4.5 mcg and 160/4.5 mcg. Your health care provider will prescribe the strength that is best for you. SYMBICORT 160/4.5 mcg is the approved dosage for COPD.

- SYMBICORT should be taken every day as 2 puffs in the morning and 2 puffs in the evening.
- Rinse your mouth with water and spit the water out after each dose (2 puffs) of SYMBICORT. This will help lessen the chance of getting a fungus infection (thrush) in the mouth and throat.
- Do not spray SYMBICORT in your eyes. If you accidentally get SYMBICORT in your eyes, rinse your eyes with water. If redness or irritation persists, call your health care provider.
- Do not change or stop any medicines used to control or treat your breathing problems. Your health care provider will change your medicines as needed
- **While you are using SYMBICORT 2 times each day, do not use other medicines that contain a long-acting beta$_2$-agonist (LABA) for any reason. Ask your health care provider or pharmacist if any of your other medicines are LABA medicines.**
- SYMBICORT does not relieve sudden symptoms. Always have a rescue inhaler medicine with you to treat sudden symptoms. If you do not have a rescue inhaler, call your health care provider to have one prescribed for you.

**Call your health care provider or get medical care right away if:**

- your breathing problems worsen with SYMBICORT
- you need to use your rescue inhaler medicine more often than usual
- your rescue inhaler does not work as well for you at relieving symptoms
- you need to use 4 or more inhalations of your rescue inhaler medicine for 2 or more days in a row
- you use one whole canister of your rescue inhaler medicine in 8 weeks' tim
- your peak flow meter results decrease. Your health care provider will tell yo the numbers that are right for you
- your symptoms do not improve after using SYMBICORT regularly for 1 wee

## WHAT MEDICATIONS SHOULD I NOT TAKE WHEN USING SYMBICORT?

While you are using SYMBICORT, do not use other medicines that contain a long-acting beta$_2$-agonist (LABA) for any reason, such as:

- Serevent® Diskus® (salmeterol xinafoate inhalation powder)
- Advair Diskus® or Advair® HFA (fluticasone propionate and salmeterol)
- Formoterol-containing products such as Foradil Aerolizer, Brovana®, or Perforomist®

## WHAT ARE THE POSSIBLE SIDE EFFECTS WITH SYMBICORT?

**SYMBICORT can cause serious side effects.**

- Increased risk of pneumonia and other lower respiratory tract infections i you have COPD. Call your health care provider if you notice any of these symptoms: increase in mucus production, change in mucus color, fever, chills, increased cough, increased breathing problems
- Serious allergic reactions including rash; hives; swelling of the face, mouth and tongue; and breathing problems. Call your health care provider or get emergency care if you get any of these symptoms
- Immune system effects and a higher chance for infections
- Adrenal insufficiency–a condition in which the adrenal glands do not make enough steroid hormones
- Cardiovascular and central nervous system effects of LABAs, such as chest pain, increased blood pressure, fast or irregular heartbeat, tremor, or nervousness
- Increased wheezing right after taking SYMBICORT
- Eye problems, including glaucoma and cataracts. You should have regula eye exams while using SYMBICORT
- Osteoporosis. People at risk for increased bone loss may have a greater risk with SYMBICORT
- Slowed growth in children. As a result, growth should be carefully monitored
- Swelling of your blood vessels. This can happen in people with asthma
- Decreases in blood potassium levels and increases in blood sugar levels

## WHAT ARE COMMON SIDE EFFECTS OF SYMBICORT

**Patients with Asthma**

Sore throat, headache, upper respiratory tract infection, thrush in the mouth and throat

**Patients with COPD**

Thrush in the mouth and throat

These are not all the side effects with SYMBICORT. Ask your health care provider or pharmacist for more information.

**NOTE: This summary provides important information about SYMBICORT. For more information, please ask your doctor or health care provider.**

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Or, call **1-866-SYMBICORT**

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★★★★★

"Great watch... an impressive piece straight out of the box."
— C. FROM COLORADO

*Suggested Retail $395... NOW, on your wrist for $49 For a limited Time Only*

# No More Mr. Nice Watch

*Forget sleek and subtle, the Stauer Colossus Hybrid is one tough timepiece...now for less than $50!*

Never underestimate your competition. Just ask Demetrius, the unfortunate Greek general who set out o conquer Rhodes in 305 BC. He assumed that a massive orce of 40,000 men, a fleet of Aegean pirates and an rsenal of wall-smashing war machines would be enough o crush the tiny Greek island. He was wrong. The Rhodians ere tougher than he thought. And so is this watch. If ou've always believed that the biggest, baddest watches ad to cost big, bad money, the $49 Stauer ***Colossus Hybrid Chronograph*** is here to change your mind.

**A monument to toughness.** The people of Rhodes were eady for Demetrius and repelled his attack. To celebrate, ey built the Colossus of Rhodes, a 107-foot bronze and on giant that towered over the harbor like a ten-story ophy. It warned future invaders that "Rhodes is tougher an you think." You give the same message when you ear the Stauer ***Colossus***.

**The timepiece that works twice as hard.** In designing e ***Colossus Hybrid Chronograph***, our instructions to the atchmaker were clear: build it as tough as a battleship nd fill it full of surprises. Make it a hybrid, because it hould work twice as hard as a regular watch. And make look like a million bucks, because when you put it n, you should get excited about rolling up your sleeves. ission accomplished.

**A toolbox on your wrist.** It will keep you on schedule, ut the ***Colossus Hybrid*** is about much more than time. he imposing case features a rotating gunmetal bezel that ames the silver, black and yellow face. You'll find a bat- lion of digital displays on the dial arranged behind a pair f luminescent hands and a bold yellow second hand. Powered by a precise quartz movement, the watch is doubly accurate in analog and digital mode. And it's packed with plenty of handy extras including a bright green EL back-light for enhanced nighttime visibility, a tachymeter along the outer dial and a full complement of alarms and split-second countdown timers. The ***Colossus Hybrid*** secures with a folded steel bracelet that highlights a row of striking dark center links. It's a rugged watch that's more than ready for your daily grind.

**Your Satisfaction is Guaranteed.** Wear the Stauer ***Colossus Hybrid*** for 30 days and if you are not 100% thrilled with your purchase, return it for a full refund of your purchase price. But once you get a taste of more watch for less money, it's likely you'll be back for more... and we'll be waiting.

WATCH SPECS: -Easy-to-read analog/digital modes -Back-lighting and luminescent hands - Tachymeter, countdown timers and alarms -Folded stainless steel bracelet fits a 6 3/4"–9" wrist

***Offer Limited to First 5000 Respondents***

**Colossus Hybrid Digital/Analog Watch—~~$395~~**

***Now* $49** +S&P ***Save $346***

*Call now to take advantage of this limited offer.*

**1-888-277-8380**

**Promotional Code CHW411-03**
Please mention this code when you call.

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# VISIONS

**Germany**
High above Bavaria's Zugspitze mountain, Swiss tightrope artist Freddy Nock nears the end of his 2011 quest to walk a two-inch-thick, 3,264-foot-long cable without a balancing pole. He succeeded, as photographers looked on.

PHOTO: MICHAELA REHLE, REUTERS

**India**
Suspended in a hammock, a boy slumbers precariously in the noontime heat of a summer day. His family relaxes nearby on a roadside in Uttar Pradesh.

PHOTO: PARIVARTAN E-NEWS, REUTERS

**India**
At twilight on flood-waters from the Brahmaputra River, a fisherman maneuvers a net on bamboo poles to catch fish for local consumption. The site lies near the city of Guwahati, a key river port in northeast India.

PHOTO, ERIC KIM

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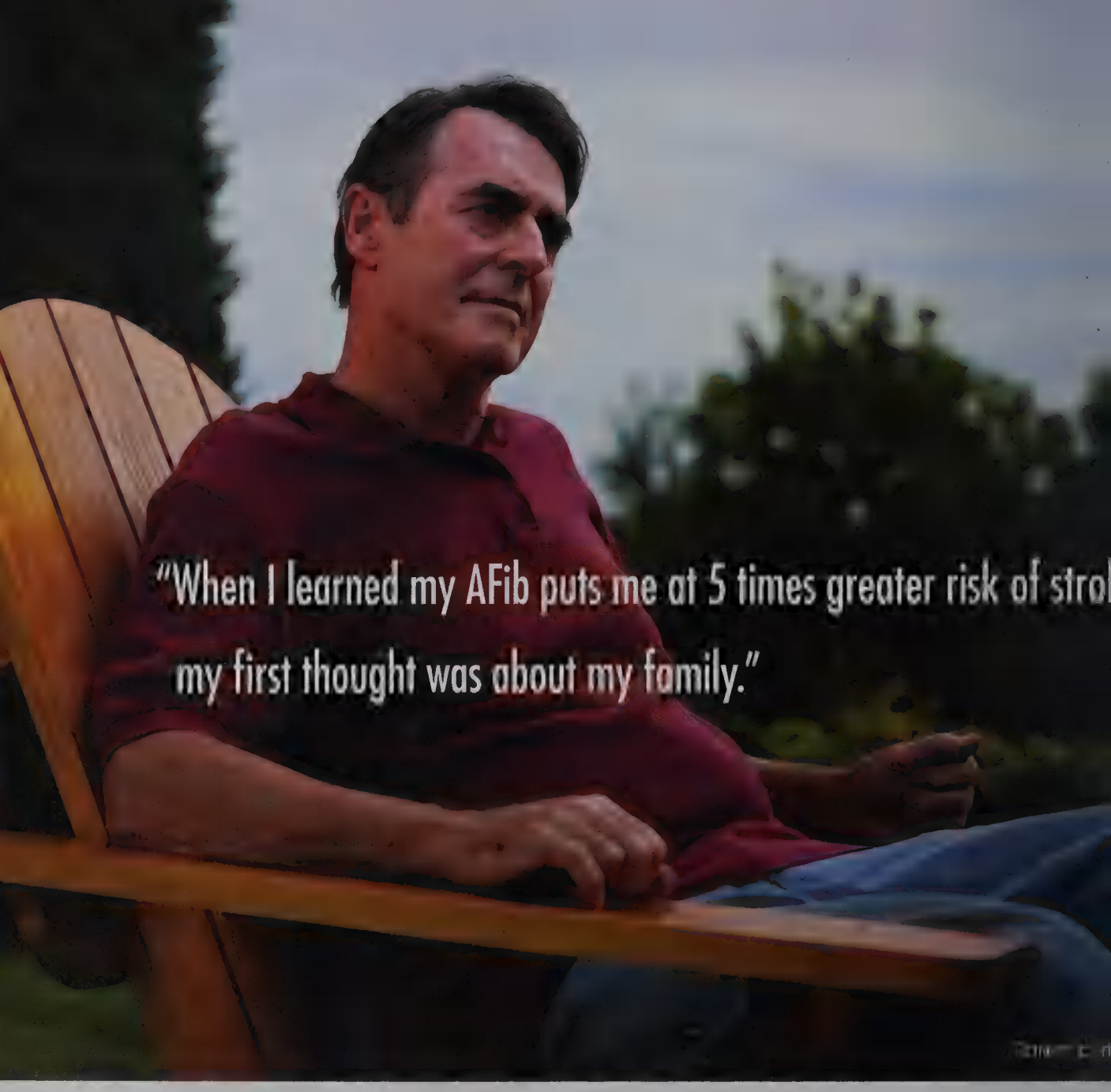


## What is Pradaxa® (dabigatran etexilate mesylate) capsules?

PRADAXA is a prescription blood-thinning medicine used to reduce the risk of stroke and blood clots in people with atrial fibrillation not caused by a heart valve problem.

## IMPORTANT SAFETY INFORMATION

PRADAXA can cause bleeding which can be serious and sometimes lead to death. Don't take PRADAXA if you currently have abnormal bleeding or if you have ever had an allergic reaction to it.

Boehringer Ingelheim

**Your risk of bleeding with PRADAXA ma be higher if you:** are 75 years old or older, hav kidney problems, have stomach or intestine bleedi that is recent or keeps coming back or you have a stomach ulcer, take other medicines that increase y risk of bleeding, like aspirin products, non-steroidal anti-inflammatory drugs (NSAIDs) and blood thinne have kidney problems and take dronedarone (Mult or ketoconazole tablets (Nizoral®).

**Call your doctor or seek immediate medic care if you have any of the following sign or symptoms of bleeding:** any unexpected, severe, or uncontrollable bleeding; or bleeding th lasts a long time, unusual or unexpected bruising, coughing up or vomiting blood; or vomit that look like coffee grounds, pink or brown urine;

If you have an irregular heartbeat called atrial fibrillation, or AFib, not caused by a heart valve problem, **PRADAXA** can reduce your risk of stroke.

- In a clinical trial, PRADAXA **reduced stroke risk 35% more** than warfarin.

Risk reduction was greatest when compared to patients on warfarin whose blood tests showed lower levels of control.

- **Unlike warfarin:**

**No regular blood tests.**
**No dietary restrictions.**

*Ask your doctor about*

Pradaxa®
dabigatran etexilate
CAPSULES 150 mg

d or black stools (looks like tar), unexpected pain, elling, or joint pain, headaches and feeling dizzy weak.

**is important to tell your doctor about all edicines, vitamins and supplements you ke. Some of your other medicines may fect the way PRADAXA works.**

**ke PRADAXA exactly as prescribed by ur doctor. Don't stop taking PRADAXA ithout talking to your doctor as your k of stroke may increase.**

your doctor if you are planning to have **any** gery, or medical or dental procedure, because you y have to stop taking PRADAXA for a short time.

PRADAXA can cause indigestion, stomach upset or burning, and stomach pain.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch or call 1-800-FDA-1088.

**Please see more detailed Medication Guide on next page.**

Pradaxa®
dabigatran etexilate
CAPSULES 150 mg

*For more information or help paying for your medication, call 1-877-PRADAXA or visit pradaxa.com.*

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Pradaxa®
dabigatran etexilate
CAPSULES 150mg

**MEDICATION GUIDE**
**PRADAXA (pra dax' a)**
**(dabigatran etexilate mesylate)**
**capsules**

Read this Medication Guide before you start taking PRADAXA and each time you get a refill. There may be new information. This Medication Guide does not take the place of talking with your doctor about your medical condition or your treatment.

**What is the most important information I should know about PRADAXA?**

- PRADAXA can cause bleeding which can be serious, and sometimes lead to death. This is because PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.
- **You may have a higher risk of bleeding if you take PRADAXA and:**
  - are over 75 years old
  - have kidney problems
  - have stomach or intestine bleeding that is recent or keeps coming back, or you have a stomach ulcer
  - take other medicines that increase your risk of bleeding, including:
    - aspirin or aspirin containing products
    - long-term (chronic) use of non-steroidal anti-inflammatory drugs (NSAIDs)
    - warfarin sodium (Coumadin®, Jantoven®)
    - a medicine that contains heparin
    - clopidogrel (Plavix®)
    - prasugrel (Effient®)
  - have certain kidney problems and also take the medicines dronedarone (Multaq®) or ketoconazole tablets (Nizoral®).

    Tell your doctor if you take any of these medicines. Ask your doctor or pharmacist if you are not sure if your medicine is one listed above.
- PRADAXA can increase your risk of bleeding because it lessens the ability of your blood to clot. While you take PRADAXA:
  - you may bruise more easily
  - it may take longer for any bleeding to stop.

**Call your doctor or get medical help right away if you have any of these signs or symptoms of bleeding:**

- unexpected bleeding or bleeding that lasts a long time, such as:
  - unusual bleeding from the gums
  - nose bleeds that happen often
  - menstrual bleeding or vaginal bleeding that is heavier than normal
- bleeding that is severe or you cannot control
- pink or brown urine
- red or black stools (looks like tar)
- bruises that happen without a known cause or get larger
- cough up blood or blood clots
- vomit blood or your vomit looks like "coffee grounds"
- unexpected pain, swelling, or joint pain
- headaches, feeling dizzy or weak

**Take PRADAXA exactly as prescribed. Do not stop taking PRADAXA without first talking to the doctor who prescribes it for you. Stopping PRADAXA may increase your risk of a stroke.**

PRADAXA may need to be stopped, if possible, for one or more days before any surgery, or medical or dental procedure. If you need to stop taking PRADAXA for **any reason**, talk to the doctor who prescribed PRADAXA for you to find out when you should stop taking it. Your doctor will tell you when to start taking PRADAXA again after your surgery or procedure.

**See "What are the possible side effects of PRADAXA?" for more information about side effects.**

**What is PRADAXA?**

PRADAXA is a prescription medicine used to reduce the risk of stroke and blood clots in people who have a medical condition called atrial fibrillation. With atrial fibrillation, part of the heart does not beat the way it should. This can lead to blood clots forming and increase your risk of a stroke. PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.

It is not known if PRADAXA is safe and works in children.

**Who should not take PRADAXA?**

**Do not take PRADAXA if you:**

- currently have certain types of abnormal bleeding. Talk to your doctor, before taking PRADAXA if you currently have unusual bleeding.
- have had a serious allergic reaction to PRADAXA. Ask your doctor if you are not sure.

**What should I tell my doctor before taking PRADAXA?**

Before you take PRADAXA, tell your doctor if you:

- have kidney problems
- have ever had bleeding problems
- have ever had stomach ulcers
- have any other medical condition

- are pregnant or plan to become pregnant. It is not known if PRADAXA will harm your unborn baby.
- are breastfeeding or plan to breastfeed. It is not known if PRADAXA passes into your breast milk.

Tell all of your doctors and dentists that you are taking PRADAXA. They should talk to the doctor who prescribed PRADAXA for you, before you have **any** surgery, or medical or dental procedure.

**Tell your doctor about all the medicines you take, including** prescription and non-prescription medicines, vitamins, and herbal supplements. Some of your other medicines may affect the way PRADAXA works. Certain medicines may increase your risk of bleeding. See "**What is the most important information I should know about PRADAXA**?"

Especially tell your doctor if you take:
- rifampin (Rifater, Rifamate, Rimactane, Rifadin)

Know the medicines you take. Keep a list of them and show it to your doctor and pharmacist when you get a new medicine.

**How should I take PRADAXA?**
- **Take PRADAXA exactly as prescribed by your doctor.**
- Do not take PRADAXA more often than your doctor tells you to.
- You can take PRADAXA with or without food.
- **PRADAXA comes in a bottle or in a blister package.**
- **Only open 1 bottle of PRADAXA at a time. Finish your opened bottle of PRADAXA before opening a new bottle.**
- **After opening a bottle of PRADAXA, use within 4 months. See "How should I store PRADAXA?"**
- **When it is time for you to take a dose of PRADAXA, only remove your prescribed dose of PRADAXA from your open bottle or blister package.**
- **Tightly close your bottle of PRADAXA right away after you take your dose.**
- Swallow PRADAXA capsules whole. Do not break, chew, or empty the pellets from the capsule.
- If you miss a dose of PRADAXA, take it as soon as you remember. If your next dose is less than 6 hours away, skip the missed dose. Do not take two doses of PRADAXA at the same time.
- Your doctor will decide how long you should take PRADAXA. **Do not stop taking PRADAXA without first talking with your doctor. Stopping PRADAXA may increase your risk of stroke.**
- Do not run out of PRADAXA. Refill your prescription before you run out. If you plan to have surgery, or a medical or a dental procedure, tell your doctor and dentist that you are taking PRADAXA. You may have to stop taking PRADAXA for a short time. See "What is the most important information I should know about PRADAXA?"
- If you take too much PRADAXA, go to the nearest hospital emergency room or call your doctor.
- Call your healthcare provider right away if you fall or injure yourself, especially if you hit your head. Your healthcare provider may need to check you.

**What are the possible side effects of PRADAXA?**
PRADAXA can cause serious side effects.
- See "What is the most important information I should know about PRADAXA?"
- Allergic Reactions. In some people, PRADAXA can cause symptoms of an allergic reaction, including hives, rash, and itching. Tell your doctor or get medical help right away if you get any of the following symptoms of a serious allergic reaction with PRADAXA:
  - chest pain or chest tightness
  - swelling of your face or tongue
  - trouble breathing or wheezing
  - feeling dizzy or faint

Common side effects of PRADAXA include:
- indigestion, upset stomach, or burning
- stomach pain

Tell your doctor if you have any side effect that bothers you or that does not go away.

These are not all of the possible side effects of PRADAXA. For more information, ask your doctor or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

**How should I store PRADAXA?**
- Store PRADAXA at room temperature between 59°F to 86°F (15°C to 30°C). After opening the bottle, use PRADAXA within 4 months. Safely throw away any unused PRADAXA after 4 months.
- **Keep PRADAXA in the original bottle or blister package to keep it dry (protect the capsules from moisture). Do not put PRADAXA in pill boxes or pill organizers.**
- **Tightly close your bottle of PRADAXA right away after you take your dose.**

**Keep PRADAXA and all medicines out of the reach of children.**

**General information about PRADAXA**
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This Medication Guide has been approved by the U.S. Food and Drug Administration.

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Grace Cleere included National Geographic in her estate plans.

A communications expert for the government, Grace Cleere recently named National Geographic as a beneficiary in her will. "I included a bequest intention to National Geographic because I believe in everything the organization represents," says Cleere. "If we don't understand our world, we are bound to mistreat it. And if we are not curious about all living things on our planet, we are bound to lose them through thoughtlessness and indifference. National Geographic shines a spotlight on the critical issues of the day and proposes innovative solutions that are grounded in science. I feel good about my legacy knowing that National Geographic will leverage my gift so it can have the greatest impact."

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This page features two photographs: one chosen by our editors and one chosen by our readers via online voting. For more information, go to *ngm.com/yourshot*.

EDITORS' CHOICE **Zhang Xuan** Toronto, Canada

On the shore of Canada's Lake Ontario, Zhang enjoyed watching the elegant feathers of mute swans. While feeding, this one opened its wings and gave the photographer the shot he'd hoped for. "My original aim was to capture the swan facing me," he says, "but this angle was good."

READERS' CHOICE

**Ko Cheng**
Taichung, Taiwan

As a medical student in Taichung, Cheng visited Gaomei wetland, a protected habitat where water sculpts the mud. The 27-year-old reflects, "Taking off one's shoes and walking on the tidal flat is the most direct way for people who live in the concrete jungle to contact nature."

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# BIG-PICTURE DEBATES IN RIO & ASPEN

## SPOTLIGHT ON SUSTAINABILITY AND ADAPTATION

### MEGASUMMIT FOSTERS KEY COMMITMENTS

Marking the 20th anniversary of the first Earth Summit, in Rio de Janeiro, heads of state from nearly 200 countries as well as 50,000 activists came to Brazil for the sprawling **Rio+20 United Nations Conference on Sustainable Development** (June 20–22, 2012). The agenda? To drive global initiatives to reduce carbon, increase clean energy, and address food and water shortages. Among his remarks, United Nations Secretary-General Ban Ki-moon said that with 1.5 billion more people in the world today than in 1992, we'll need 50 percent more food and 45 percent more energy in 2030 than we do now. The three-day event drew mixed reviews and produced a sizable outcome document entitled "The Future We Want." But words translated into action with some of the world's largest companies agreeing to take deforestation out of food supply chains and proposing to roll out internal carbon fees on operations throughout the world. Another significant side meeting brought about commitments from development banks, now poised to lend billions of dollars to major cities to lessen congestion, pollution, and energy waste.

### FINITE RESOURCES, EXPANDING NEEDS

Later that week, 6,000 miles northwest, the sustainability conversation continued when distinguished thought leaders and interested citizens convened at the fifth annual **Aspen Environment Forum** (June 22–25, 2012) for dialogue surrounding the theme of "Living in the New Normal." The National Oceanic and Atmospheric Administration's recent declaration that the long-term average temperature in the U.S. has warmed by a half degree in the past decade set the baseline for discussions on how to adapt to the new environmental paradigm. The forum permitted insightful exchanges among experts such as Edward O. Wilson, Stewart Brand, Fred Krupp, and Sylvia Earle, among many others. In its goal to illuminate ways to preserve the Earth's finite resources, developments in urbanization were presented along with improvements in freshwater conservation, technologies, and energy-efficient alternatives. These and other solutions are helping us meet some of the greatest challenges of our time.

*Vale continues to support and encourage dialogue on critical sustainability issues.*

VALE

*Learn more at* ***nationalgeographic.com/sustainable-earth.***

↑↓ *Photos: Daniel Bayer*

Botafogo Bay, Rio de Janeiro, Brazil *(top).*

Elliot Gerson, Executive Vice President for Policy and Public Programs, International Partners, The Aspen Institute at left; Edward O. Wilson, University Research Professor Emeritus, Harvard University right *(above right).*

Attendees at The Aspen Institute Campus *(right).*

# NEXT

SKYCAST

*Overhead this month in parts of the world*

*October 21*
**Orionids meteor shower**

## Choice Words

Reading this page starts with the ability to distinguish real words from garble by identifying letters and their relationship to one another. Baboons, a new study reveals, have that skill too—countering a common theory that reading requires prior knowledge of language.

Researchers at France's Aix-Marseille University presented four-letter combinations to six Guinea baboons, which touched one of two shapes on a screen to indicate word or nonword. After some 10,000 attempts each, they could spot actual words with nearly 75 percent accuracy—and could even predict whether a new sequence was a word. The results suggest that human reading might involve recognizing letters purely as objects, rather than symbols associated with spoken language, says co-author Jonathan Grainger. The next step: seeing if baboons can connect words with meaning. *—Luna Shyr*

*Baboons learned to identify English words (in brown) from nonwords (blue) with up to 75 percent accuracy.*

ART: SARAH KING

# A new tyrannosaur is the largest feathered animal ever found.

**DOWNY DINOSAUR** | Kin to the mighty *T. rex*, 30-foot-long carnivorous *Yutyrannus huali*—a mix of Mandarin and Latin that translates to "beautiful feathered tyrant"—is the first big dinosaur known to have feathers. Three near-complete fossils of the dinosaur discovered in China's Liaoning Province are streaked with remnants of eight-inch filaments—an indication that the one-ton predator had a downy coat, like a supersize chick, says Corwin Sullivan, a paleontologist at the Chinese Academy of Sciences who's studying the new species.

Unlike the stiff quills of modern birds meant for flight, *Y. huali*'s soft down may have kept the animal toasty during a Cretaceous cold spell about 125 million years ago. Did big dinosaurs need feathers for warmth? Modern biology would suggest not, since large living animals retain heat better than small ones. But the *Y. huali* find, added to numerous smaller feathered dinosaur species unearthed in the same rock formation, points to yes. "Now we have evidence, and it's quite a large tyrannosauroid that apparently did need insulation," says Sullivan. "It changes the picture." —*Christine Dell'Amore*

head-to-foot fossils of *Y. huali* have streaks along their length—remnants of feathers up to eight inches long.

PHOTOS: ROBERT CLARK, RAMIREZ MATHEW TWINE; NGM STAFF; AND XING LIDA

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*Above: A kayaker paddles in the clear blue waters of Belize.*

# Elephant Toys

Known affectionately as "the girls," Ruth and Emily have a lot of fun for two Asian elephants. Ages 54 and 48, they spend their days tinkering with an array of special toys at the Buttonwood Park Zoo in Massachusetts. No mere plastic playthings, these toys have been engineered to appeal to the pachyderms' social nature, psychology, and intelligence.

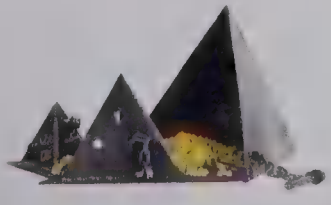
The toymakers are students from the Massachusetts College of Art and Design, assigned to create elephant gadgets after research excursions to the zoo. "The class discovered that the elephants first want to play with a new object in the yard, then try to eat it," says Professor Rick Brown. That's why a crank-operated canister (right) is packed with popcorn; other toys have fruit tucked inside.

Typically the elephants find and finish off the treats within a half hour, says zoo director William Langbauer. He reports that the girls haven't rejected any toy yet but sometimes use them in surprising ways. A steel box with the word "elephant" cut into it, for example, is meant to be a puzzle. Emily prefers to bang it like a drum.

*—Catherine Zuckerman*

Balls inside the Octo-log make noise when it's rolled.

The 425-pound Pachy-sac, made of tire treads, is a favorite.

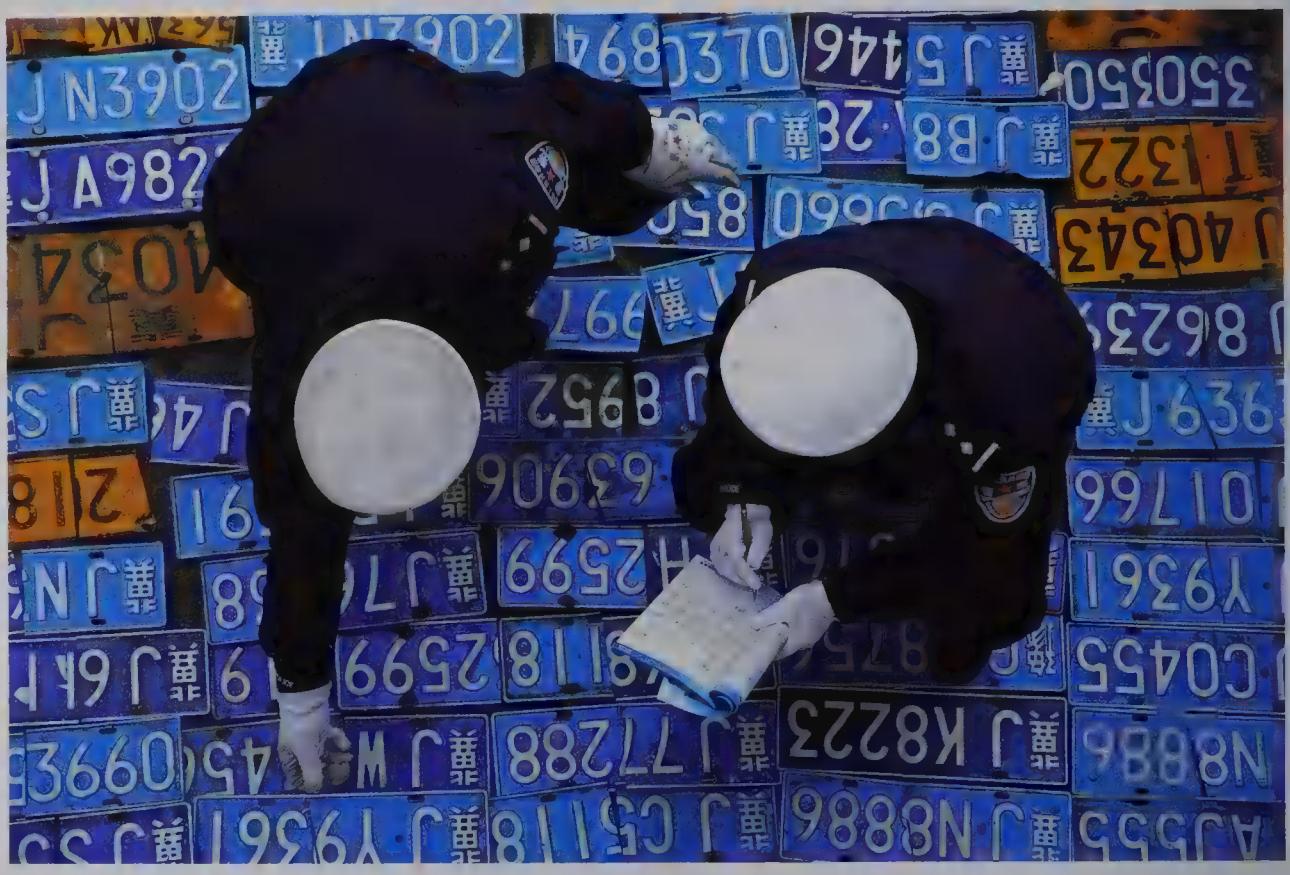


Twisting a bolt unlocks the treat-filled Pyramid Toy.

Toys designed by art students are a hit with elephants at a Massachusetts zoo.

PHOTOS: CARY WOLINSKY

The South Pole's winter temperature averages 36°F colder than the North Pole's.



*In Cangzhou, Chinese police check counterfeit license plates as part of a campaign against illegal vehicles.*

## China's Car Crackdown

With Chinese cities choking on traffic—the number of cars has more than doubled since 2007—governments are struggling to prevent permanent gridlock. Beijing has chosen the radical solution of holding a lottery for 20,000 license plates each month, with about 900,000 total applicants.

That's forcing Beijingers to take countermeasures. Some enroll family members to boost their odds; others buy cars registered in neighboring cities. Shanghai auctions plates to the tune of $10,000 each, while other cities are raising downtown parking fees or building subway lines. "Gridlock should be avoidable," says Shao Chunfu of Beijing Jiaotong University. "But given trends in China's development, I'm afraid it's unavoidable, even in small cities." *—Ian Johnson*

**PASSING THE TEST** To combat [illegible] than 60,000 traffic deaths each year, China requires [illegible] drivers [illegible] a tough test. They must [illegible] percent [illegible] drawn from hundreds of possible questions on topics [illegible] road judgment, etiquette, and civil law. *—IJ*

See more driving-test questions on the iPad.

**Sample question ▶** **When a vehicle overturns slowly and jumping out of the vehicle is possible, the driver should jump _____.**

**A.** in the driving direction
**B.** in the overturning direction
**C.** in the opposite direction of the overturn
**D.** to the overturning side

ANSWER: C

PHOTO: COLOR CHINA PHOTO/AP IMAGES. GRAPHIC: SIWEN LI. SOURCE: WOODS HOLE OCEANOGRAPHIC INSTITUTION

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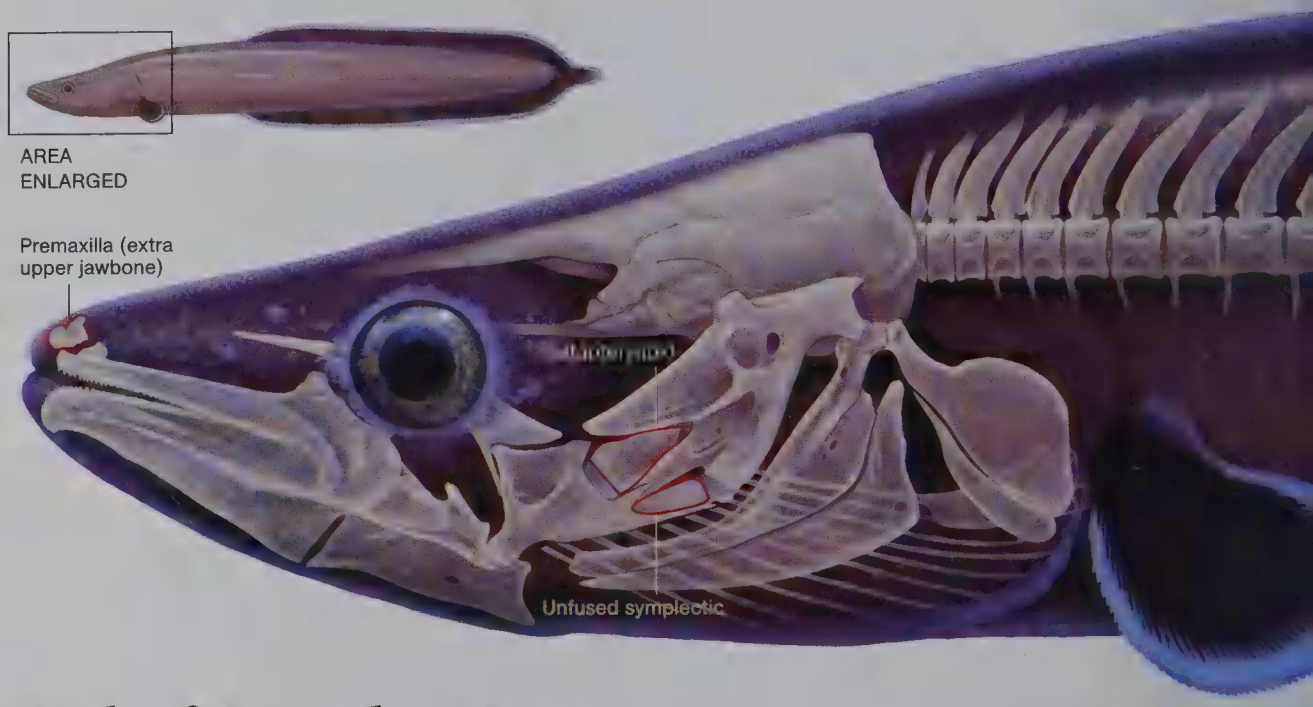


# Eel of Another Era

Age and beauty, it seems, may not be mutually exclusive. A comely eel displaying anatomical features not seen in its kin for 140 million years has prompted the rare creation of a new family of fish. Researchers dubbed the purplish, ribbonlike *Protanguilla palau* a living fossil—a descriptor for creatures (like the coelacanth) largely unaltered since ancient times. Discovered in 2009 in a reef cave off the Republic of Palau, the eel sports an extra upper jawbone, characteristic of its Cretaceous-period brethren. It also has fewer than 90 vertebrae, an even more primitive feature. Other traits raised doubts that it was a true eel until anatomical and molecular analysis confirmed the classification, says the Smithsonian Institution's G. David Johnson, lead author of the findings. *—John Briley*

*Ancient structures (in red) make* Protanguilla palau *the most primitive eel of all. Collected specimens range from 1.7 to 7 inches long.*

## The Beetle and the Bottle

It [redacted] a twisted love story—insect and inanimate object. But to [redacted] two-inch Australian jewel beetle, [redacted] discarded brown beer bottle looks like [redacted] extra-large female. Bemused, [redacted] males make what Darryl Gwynne of the University of Toronto calls [redacted] "mating mistake." Larger partners [redacted] incredibly enticing—"superstimuli," Gwynne says—because bigger females [redacted] eggs to fertilize. Most often, it's [redacted] fatal attraction for persistent males. Beetles that approach from the top exhaust themselves and fry in the sun; those with a foot [redacted] the ground may end up [redacted] meal for ants. *—Johnna Rizzo*

ART: RAÚL MARTÍN. SOURCE: G. DAVID JOHNSON, SMITHSONIAN NATIONAL MUSEUM OF NATURAL HISTORY
NGM MAPS. PHOTO: JIRI LOCHMAN, LOCHMAN TRANSPARENCIES

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## Power Flower

Chinese herbalists have long relied on the roots of the blue evergreen hydrangea *(Dichroa febrifuga)* to treat malaria. In the 1960s scientists derived the compound halofuginone from the plant's active ingredient but side effects stymied many efforts to turn it into mainstream medicine.

Now cell biologists Tracy Keller and Malcolm Whitman are deciphering how halofuginone works. They've found that it tricks cells into starvation mode—essentially switching off the inflammatory processes that trigger many autoimmune symptoms. They hope to pave the way for new treatments for diseases like multiple sclerosis, Crohn's, lupus, and arthritis.

Such tricks could also boost fat burning and help combat aging. Says Keller, "We're tapping into a signal that tells cells: Eat less. Get handy. Live longer. Get less inflamed." *—Aaron Newell*

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A three-toed sloth can cover a distance of 15 feet—about nine times its body length—in one minute.

Ambergris's scent varies from piece to piece—salty to animalish to earthy. Whiter chunks often smell sweet, some like vanilla.

## Landmassive

Amasia—named for the crash and subsequent connection of the Americas and Asia—will fuse in 100 million years. It won't be ■ first. The Earth's landmasses are constantly shifting, all together—a supercontinent—then apart again, ■■ faster than a fingernail grows. The most recent convergence, Pangaea, formed 300 million years ago; Rodinia, 1.1 billion; Nuna, 1.8 billion.

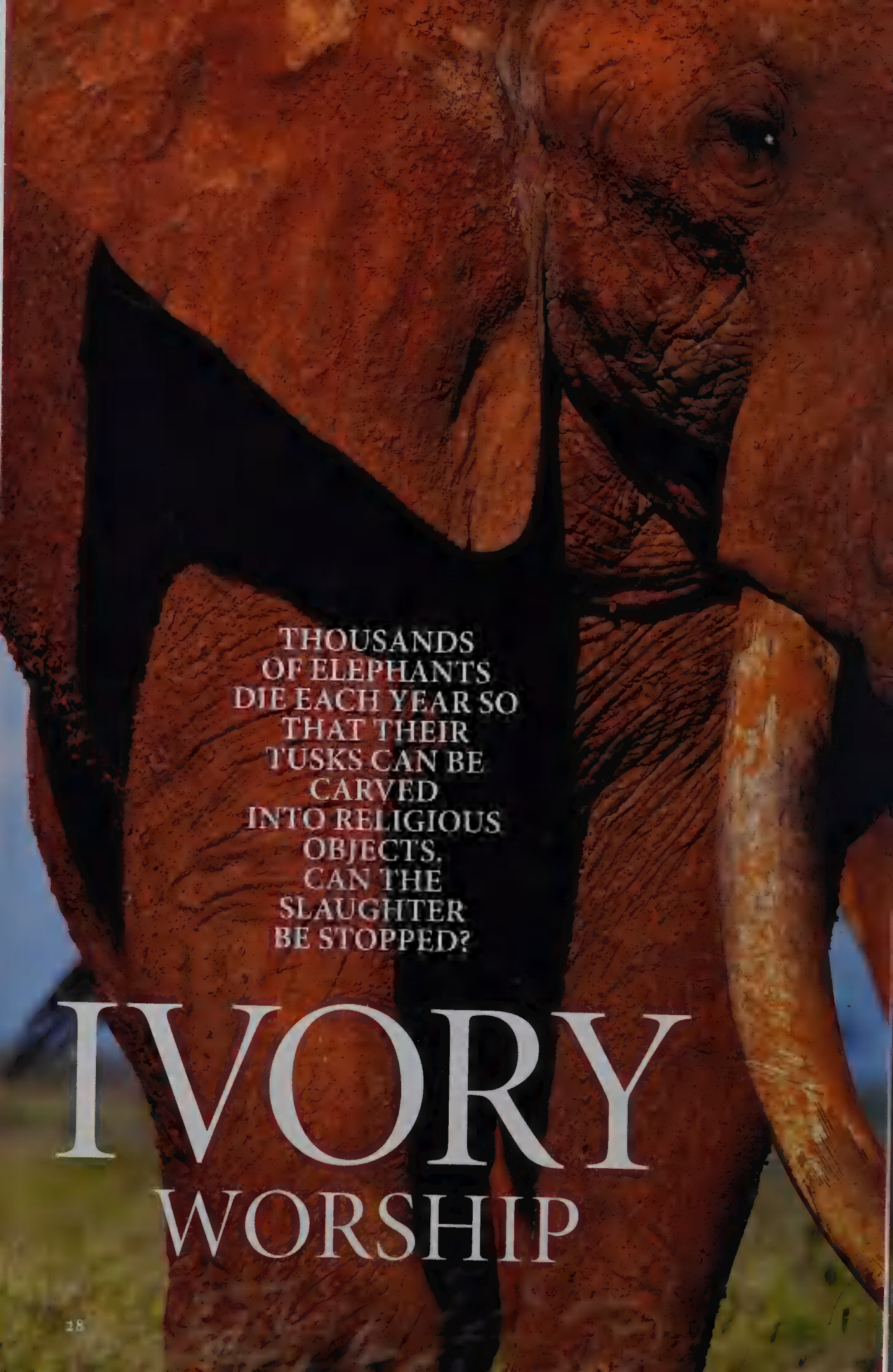
Most theories of Amasia's creation show the Atlantic seafloor stretching or being swallowed, but geologist Ross Mitchell's model, using paleomagnetic data from ancient rocks, predicts the Arctic Ocean will close up instead, the supercontinent sliding north into its place. Where the rebroken land goes from there is unknown. "It's not like an accordion, in and out," says Mitchell. *—JR*

Amasia about 100 million years from now, as it begins to form

## Eau de Whale

Ambergris is the unlikeliest of perfume ingredients. The nuggets start forming as a slurry in the guts of sperm whales around stomach irritants like squid beaks, then are ejected into the ocean. (Once thought to be spewed, they're now believed to be excreted.) The scent is said to be dunglike at first but grows musky after exposure to seawater and air. For centuries perfumers have capitalized on the ability of ambergris, which is collected along shorelines, to amplify fragrances and fix them to the skin. But the sea mammal's endangered status might limit supply, so nonanimal options are being explored. Among them: Molecular biologist Joerg Bohlmann's team has found a way to reproduce a balsam fir compound that provides a perfume fixative, without cetacean input. *—Johnna Rizzo*

PHOTOS: DAVID LIITTSCHWAGER. GRAPHIC: ÁLVARO VALIÑO. SOURCE: MARK CARWARDINE, *NATURAL HISTORY MUSEUM ANIMAL RECORDS*. NGM MAPS. SOURCE: YALE PALEOMAGNETICS GROUP


THOUSANDS OF ELEPHANTS DIE EACH YEAR SO THAT THEIR TUSKS CAN BE CARVED INTO RELIGIOUS OBJECTS. CAN THE SLAUGHTER BE STOPPED?

# IVORY WORSHIP

Some of the last big tuskers grazing in Tsavo, Kenya. A single large tusk sold on the local black market can bring $6,000, enough to support an unskilled Kenyan worker for ten years.

INORI

The largest ivory crucifix in the Philippines (left) hangs in a museum in Manila. The body of Christ, 30 inche
long, is carved from a single tusk. The piece dates to the early 1600s, when Spanish galleons began bring

Asian ivory craftsmanship to Spain and the New World. The home of a Filipino collector (above) is lavish with ivory religious icons. "I don't see the elephant," says another Filipino collector. "I see the Lord."

Bodies are what remain in Cameroon's Bouba Ndjidah National Park after one of the largest mass elephant slaughters in decades. Armed with grenades and AK-47's, poachers killed more than 300.

A worker in China's largest ivory carving factory finishes a piece symbolizing prosperity. China legally bought 73 tons of ivory from Africa in 2008; since then, poaching and smuggling have both soared.

BY BRYAN CHRISTY
PHOTOGRAPHS BY BRENT STIRTON

**IN JANUARY 2012 A HUNDRED RAIDERS ON HORSEBACK CHARGED OUT OF CHAD INTO CAMEROON'S BOUBA NDJIDAH NATIONAL PARK, SLAUGHTERING HUNDREDS OF ELEPHANTS**—entire families—in one of the worst concentrated killings since a global ivory trade ban was adopted in 1989. Carrying AK-47s and rocket-propelled grenades, they dispatched the elephants with a military precision reminiscent of a 2006 butchering outside Chad's Zakouma National Park. And then some stopped to pray to Allah. Seen from the ground, each of the bloated elephant carcasses is a monument to human greed. Elephant poaching levels are currently at their worst in a decade, and seizures of illegal ivory are at their highest level in years. From the air too the scattered bodies present a senseless crime scene—you can see which animals fled, which mothers tried to protect their young, how one terrified herd of 50 went down together, the latest of the tens of thousands of elephants killed across Africa each year. Seen from higher still, from the vantage of history, this killing field is not new at all. It is timeless, and it is now.

## THE PHILIPPINES CONNECTION

In an overfilled church Monsignor Cristobal Garcia, one of the best known ivory collectors in the Philippines, leads an unusual rite honoring the nation's most important religious icon, the Santo Niño de Cebu (Holy Child of Cebu). The ceremony, which he conducts annually on Cebu, is called the Hubo, from a Cebuano word meaning "to undress." Several altar boys work together to disrobe a small wooden statue of Christ dressed as a king, a replica of an icon devotees believe Ferdinand Magellan brought to the island in 1521. They remove its small crown, red cape, and tiny boots, and strip off its surprisingly layered underwear. Then the monsignor takes the icon, while altar boys conceal it with a little white towel, and dunks it in several barrels of water, creating his church's holy water for the year, to be sold outside.

Garcia is a fleshy man with a lazy left eye and bad knees. In the mid-1980s, according to a 2005 report in the *Dallas Morning News* and a related lawsuit, Garcia, while serving as a priest at St. Dominic's of Los Angeles, California, sexually abused an altar boy in his early teens and was dismissed. Back in the Philippines, he was promoted to monsignor and made chairman of Cebu's Archdiocesan Commission on Worship. That made him head of protocol for the country's largest Roman Catholic archdiocese, a flock of nearly four million people in a country of 75 million Roman Catholics, the world's third largest Catholic population. Garcia is known beyond Cebu. Pope John Paul II blessed his Santo Niño during Garcia's visit to the pope's summer residence, Castel Gandolfo, in 1990. Recently Garcia helped direct the installation of Cebu's newest archbishop in a cathedral filled with Catholic leaders, including 400 priests and 70 bishops, among them the Vatican's ambassador. Garcia is so well known that to find his church, the Society of the Angels of Peace, I need only roll down my window and ask, "Monsignor Cris?" to be pointed toward his walled compound.

Some Filipinos believe the Santo Niño de Cebu is Christ himself. Sixteenth-century Spaniards declared the icon to be miraculous and used it to

Smugglers failed to get this contraband past Kenya's law enforcement, but the animals are still gone. Small tusks indicate that young elephants were poached.

convert the nation, making this single wooden statue, housed today behind bulletproof glass in Cebu's Basilica Minore del Santo Niño, the root from which all Filipino Catholicism has grown. Earlier this year a local priest was asked to resign after allegedly advising his parishioners that the Santo Niño and images of the Virgin Mary and other saints were merely statues made of wood and cement.

"If you are not devoted to the Santo Niño, you are not a true Filipino," says Father Vicente Lina, Jr. (Father Jay), director of the Diocesan Museum of Malolos. "Every Filipino has a Santo Niño, even those living under the bridge."

Each January some two million faithful converge on Cebu to walk for hours in procession with the Santo Niño de Cebu. Most carry miniature Santo Niño icons made of fiberglass or wood. Many believe that what you invest in devotion to your own icon determines what blessings you will receive in return. For some, then, a fiberglass or wooden icon is not enough. For them, the material of choice is elephant ivory.

I press through the crowd during Garcia's Mass, but instead of standing before him to receive Communion, I kneel.

"The body of Christ," Garcia says.

"Amen," I reply, and open my mouth.

After the service I tell Garcia I'm from *National Geographic,* and we set a date to talk about the Santo Niño. His anteroom is a mini-museum dominated by large, glass-encased religious figures whose heads and hands are made of ivory: There is an ivory Our Lady of the Rosary holding an ivory Jesus in one, a near-life-size ivory Mother of the Good Shepherd seated beside an ivory Jesus in another. Next to Garcia's desk a solid ivory Christ hangs on a cross.

Filipinos generally display two types of ivory *santos:* either solid carvings or images whose heads and hands, sometimes life-size, are ivory,

---

*Investigative reporter Bryan Christy's January 2010 story, "The Kingpin," exposed wildlife trafficker Anson Wong. Documentary photographer Brent Stirton's March 2012 "Rhino Wars" won a World Press award.*

while the body is wood, providing a base for lavish capes and vestments. Garcia is the leader of a group of prominent Santo Niño collectors who display their icons during the Feast of the Santo Niño in some of Cebu's best shopping malls and hotels. When they met to discuss formally incorporating their club, an attorney member cried out to the group, "You can pay me in ivory!"

I tell Garcia I want to buy an ivory Santo Niño in a sleeping position. "Like this," I say, touching a finger to my lower lip. Garcia puts a finger to his lip too. "*Dormido* style," he says approvingly.

My goal in meeting Garcia is to understand his country's ivory trade and possibly get a lead on who was behind 5.4 tons of illegal ivory seized by customs agents in Manila in 2009, 7.7 tons seized there in 2005, and 6.1 tons bound for the Philippines seized by Taiwan in 2006. Assuming an average of 22 pounds of ivory per elephant, these seizures represent about 1,745 elephants. According to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the treaty organization that sets international wildlife trade policy, the Philippines is merely a transit country for ivory headed to China. But CITES has limited resources. Until last year it employed just one enforcement officer to police more than 30,000 animal and plant species. Its assessment of the Philippines doesn't square with what Jose Yuchongco, chief of the Philippine customs police, told a Manila newspaper not long after making a major seizure in 2009: "The Philippines is a favorite destination of these smuggled elephant tusks, maybe because Filipino Catholics are fond of images of saints that are made of ivory." On Cebu the link between ivory and the church is so strong that the word for ivory, *garing*, has a second meaning: "religious statue."

## THE CATHOLIC-MUSLIM UNDERGROUND

"Ivory, ivory, ivory," says the saleswoman at the Savelli Gallery on St. Peter's Square in Vatican City. "You didn't expect so much. I can see it in your face." The Vatican has recently demonstrated a commitment to confronting transnational criminal problems, signing agreements on drug trafficking, terrorism, and organized crime. But it has not signed the CITES treaty and so is not subject to the ivory ban. If I buy an ivory crucifix, the saleswoman says, the shop will have it blessed by a Vatican priest and shipped to me.

Although the world has found substitutes for every one of ivory's practical uses—billiard balls, piano keys, brush handles—its religious use is frozen in amber, and its role as a political symbol persists. Last year Lebanon's President Michel Sleiman gave Pope Benedict XVI an ivory-and-gold thurible. In 2007 Philippine President Gloria Macapagal-Arroyo gave an ivory Santo Niño to Pope Benedict XVI. For Christmas in 1987 President Ronald Reagan and Nancy Reagan bought an ivory Madonna originally presented to them as a state gift by Pope John Paul II. All these gifts made international headlines. Even Kenya's President Daniel arap Moi, father of the global ivory ban, once gave Pope John Paul II an elephant tusk. Moi would later make a bigger symbolic gesture, setting fire to 13 tons of Kenyan ivory, perhaps the most iconic act in conservation history.

Father Jay is curator of his archdiocese's annual Santo Niño exhibition, which celebrates the best of his parishioners' collections and fills a two-story building outside Manila. The more than 200 displays are drenched in so many fresh flowers and enveloped in such soft "Ave Maria" music that I'm reminded of a funeral as I look at the pale bodies dressed up like tiny kings. Ivory Santo Niños wear gold-plated crowns, jewels, and Swarovski crystal necklaces. Their eyes are hand-painted on glass imported from Germany. Their eyelashes are individual goat hairs. The gold thread in their capes is real, imported from India.

The elaborate displays are often owned by families of surprisingly modest means. Devotees have opened bankbooks in the names of their ivory icons. They name them in their wills. "I don't call it extravagant," Father Jay says. "I call it an offering to God." He surveys the child images, some of which are decorated in *lagang*, silvery mother of pearl flowers carved from nautilus shells. "When it comes to Santo Niño devotion,"

he says, "too much is not enough. As a priest, I've been praying, 'If all of this stuff is plain stupid, then God, put a stop to this.'"

Father Jay points to a Santo Niño holding a dove. "Most of the old ivories are heirlooms," he says. "The new ones are from Africa. They come in through the back door." In other words, they're smuggled. "It's like straightening up a crooked line: You buy the ivory, which came from a hazy origin, and you turn it into a spiritual item. See?"

**ALTHOUGH THE WORLD HAS SUBSTITUTES FOR ALL OF IVORY'S PRACTICAL USES, ITS RELIGIOUS USE IS FROZEN IN AMBER.**

[redacted]

he says, with a giggle. His voice lowers to a whisper. "Because it's like buying a stolen item."

People should buy new ivory icons, he says, to avoid swindlers who use tea or even Coca-Cola to stain ivory to look antique. "I just tell them to buy the new ones, so the history of an image would start in you."

When I ask how new ivory gets to the Philippines, he tells me that Muslims from the southern island of Mindanao smuggle it in. Then, to signal a bribe, he puts two fingers into my shirt pocket. "To the coast guards, for example," he says. "Imagine from Africa to Europe and to the Philippines. How long is that kind of trip by boat?" He puts his fingers in my pocket again. "And you just keep on paying so many people so that it will enter your country."

It's part of one's sacrifice to the Santo Niño—smuggling elephant ivory as an act of devotion.

### HOW TO SMUGGLE IVORY

I had no illusions of linking Monsignor Garcia to any illegal activity, but when I told him I wanted an ivory Santo Niño, the man surprised me. "You will have to smuggle it to get it into the U.S."

"How?"

"Wrap it in old, stinky underwear and pour ketchup on it," he said. "So it looks shitty with blood. This is how it is done."

Garcia gave me the names of his favorite ivory carvers, all in Manila, along with advice on whom to go to for high volume, whose wife overcharges, who doesn't meet deadlines. He gave me phone numbers and locations. If I wanted to smuggle an icon that was too large to hide in my suitcase, I might get a certificate from the National Museum of the Philippines declaring my image to be antique, or I could get a carver to issue a paper declaring it to be imitation or alter the carving date to before the ivory ban. Whatever I decided to commission, Garcia promised to bless it for me. "Unlike those animal-nut priests who will not bless ivory," he said.

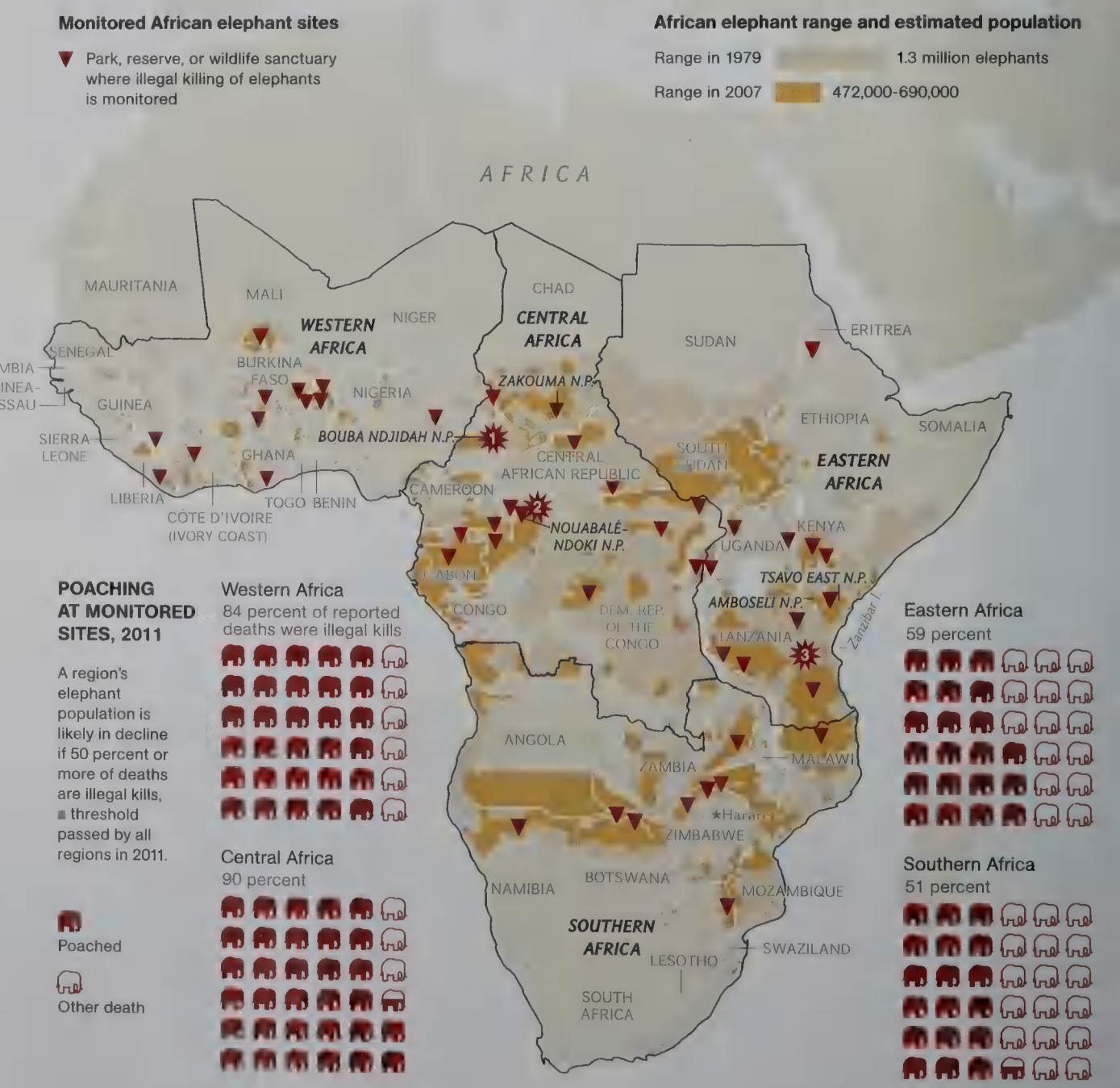
A few families control most of the ivory carving in Manila, moving like termites through massive quantities of tusks. Two of the main dealers are based in the city's religious-supplies district, Tayuman. During my five trips to the Philippines I visited every one of the ivory shops Garcia recommended to me and more, inquiring about buying ivory. More than once I was asked if I was a priest. In almost every shop someone proposed a way I could smuggle ivory to the U.S. One offered to paint my ivory with removable brown watercolor to resemble wood; another to make identical hand-painted statuettes out of resin to camouflage my ivory baby Jesus. If I was caught, I was told to lie and say "resin" to U.S. Customs. During one visit a dealer said Monsignor Garcia had just called and suggested that since I'd mentioned that my family had a funeral business, I might take her new, 20-pound Santo Niño home by hiding it in the bottom of a casket. I said he must have been joking, but she didn't think so.

Priests, *balikbayans* (Filipinos living overseas), and gay Filipino men are major customers, according to Manila's most prominent ivory dealer. An antique dealer from New York City makes regular buying missions, as does a dealer from Mexico City, gathering up new ivory

Kruba Dhammamuni, aka the Elephant Monk, keeps Asian elephants at his temple in Thailand. Activists accuse him of starving one elephant to use its ivory for amulets, a charge he rejects.

# ELEPHANT POACHING

Killing African elephants for their ivory is devastating a species that's already losing ground to a growing human population. Estimates of poaching come from examining elephant carcasses at monitored sites (map). In 2011 poaching hit the highest levels in a decade, with the greatest impact in the central Africa region (charts below).




## LARGE-SCALE POACHING

**1 Cameroon, early 2012**
Organized raiders on horseback from Chad and Sudan killed more than 300 elephants in Bouba Ndjidah National Park.

**2 Congo, 2006-2011**
Nearly 5,000 elephants died in lands outside Nouabalé-Ndoki National Park; new logging roads make the area more accessible.

**3 Tanzania, 2012**
Poachers are using poison so gunshots won't attract park wardens. Tanzania is a main shipping point for illegal ivory to Asia.

NGM STAFF; AFRICAN ELEPHANT DATA: CITES MIKE PROGRAMME; IAIN DOUGLAS-HAMILTON, SAVE THE ELEPHANTS; DIANE SKINNER, AFRICAN ELEPHANT SPECIALIST GROUP, IUCN

# IVORY SEIZURES

Most of the world's countries agreed to ban international trade in ivory in 1989. Yet demand has grown in Asia, driven by new wealth in China. The illegal ivory that is seized represents only a fraction of what gets through—and the number of large seizures has risen, evidence of organized smuggling syndicates.

*ASIAN ELEPHANTS*
*Habitat loss is the greatest threat to the estimated 40,000 left in the wild, but poaching may be on the rise.*

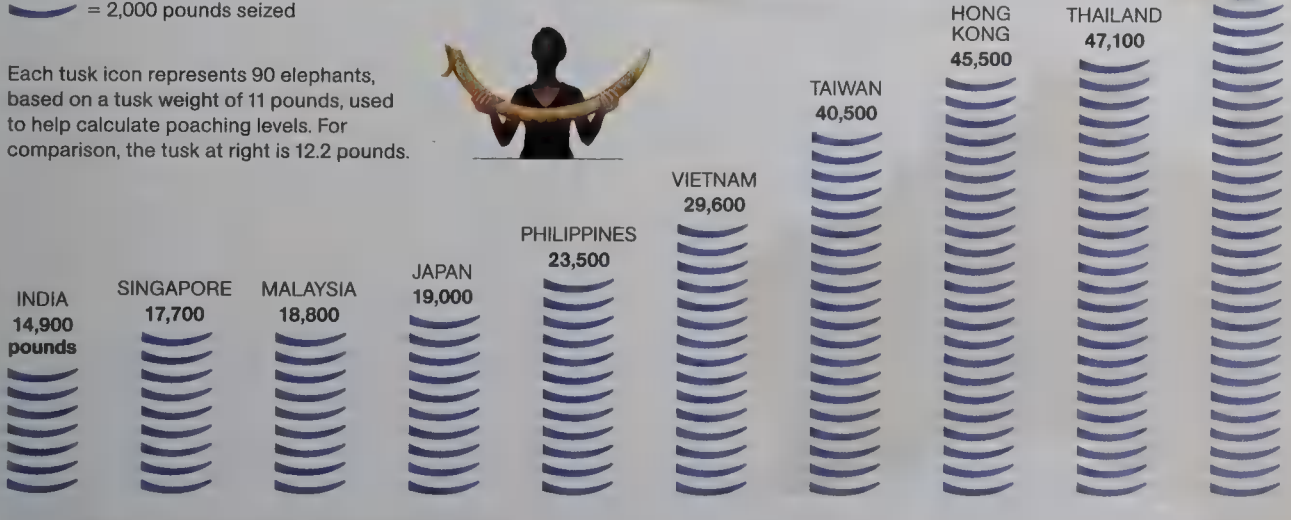
## TEN ASIAN COUNTRIES WITH THE MOST IVORY SEIZED, 1989-2011

Total weight of seizures in pounds by country or region*

= 2,000 pounds seized

Each tusk icon represents 90 elephants, based on a tusk weight of 11 pounds, used to help calculate poaching levels. For comparison, the tusk at right is 12.2 pounds.






*HONG KONG AND TAIWAN DATA COLLECTED SEPARATELY FROM CHINA'S

## SMUGGLING TACTICS

**1 Bangkok, Thailand, 2011**
An x-ray scan found 247 large tusks, valued by authorities at $3 million, in a shipping container of frozen mackerel from Kenya.

**2 Malaysia, 2011**
Shipping containers of recycled plastic from Tanzania also held nearly 700 tusks destined for China via Malaysia.

**3 Guangdong Province, China, 2009**
A rented Chinese fishing boat returned from the Philippines with 770 whole and partial tusks packed in five wooden crates.

ORY SEIZURE DATA: TOM MILLIKEN, ETIS TRAFFIC. TUSK: SMITHSONIAN NATIONAL MUSEUM OF NATURAL HISTORY, COLLECTED 1909

crucifixes, Madonnas, and baby Jesuses in bulk and smuggling them home in their luggage. Wherever there is a Filipino, I was often reminded, there is an altar to God.

And it seems Father Jay was right about a Muslim supply route. Several Manila dealers told me the primary suppliers are Filipino Muslims with connections to Africa. Malaysian Muslims figured into their network too. "Sometimes they bring it in bloody, and it smells bad," one dealer told me, pinching her nose.

Today's ivory trafficking follows ancient trade routes—accelerated by air travel, cell phones, and the Internet. Current photos I'd seen of ivory Coptic crosses on sale beside ivory Islamic prayer beads in Cairo's market now made more sense. Suddenly, recent ivory seizures on Zanzibar, an Islamic island off the coast of Tanzania—for centuries a global hub for trafficking slaves and ivory—seemed especially ominous, a sign that large-scale ivory crime might never go away. At least one shipment had been headed for Malaysia, where several multi-ton seizures were made last year.

The Philippines' ivory market is small compared with, say, China's, but it is centuries old and staggeringly obvious. Collectors and dealers share photographs of their ivories on Flickr and Facebook. CITES, as administrator of the 1989 global ivory ban, is the world's official organization standing between the slaughter of the 1980s—in which Africa is said to have lost half its elephants, more than 600,000 in just those ten years—and the extermination of the elephant. If CITES has overlooked the Philippines' ivory trade, what else has it missed?

## THE ELEPHANT MONK

The ivory carvers in Phayuha Khiri and Surin are the most famous in Thailand and the targets of most investigations there into the illegal ivory trade. Phayuha Khiri is so dedicated to ivory that in the town center, where one might expect to see a fountain, there's a circle of four great white tusks. It takes me only minutes on the main street to realize I've seen this place before: Tayuman, Manila's religious-supplies district; only here, instead of crucifixes and images of the holy family, are life-size images of famous monks, small images of the Buddha wrapped in plastic, and bracelets and other religious items bagged by the dozens. Vendor after vendor on both sides of this long street is a Buddhist wholesale outlet. The only people I see shopping during my visits to Phayuha Khiri are small knots of orange-robed monks.

I track down the village's head ivory dealer—Mr. Thi, who's wearing an amulet on an ivory necklace and an ivory belt buckle—tour his shops and carving operation, and also visit his McMansion-size home. Mr. Thi tells me that Phayuha Khiri's carving industry was founded by a monk who liked to carve ivory amulets. Standing in his shop, I look over his shoulder and see a painting of Ganesh, the elephant-headed Hindu god, and beside him a Happy Buddha. Monks, I discover, give out amulets in return for donations. The better the donation, the better the amulet. Amulets blessed by certain monks are even more valuable.

The Elephant Monk, Kruba Dharmamuni, who used to be the Scorpion Monk and still displays a life-size statue of himself as a scorpion in his temple, wants to take me ivory shopping in Surin. Once upon a time Surin was home to the king of Siam's royal elephant catchers, but today government-subsidized elephant keepers, mahouts, live a shadow of their old lives, dependent on their animals' ability to kick a soccer ball or hold a paintbrush and create a "self-portrait" on an easel for tourists. Vendors selling ivory rings, bangles, and amulets line the entrance to Surin's tourist park.

"Ivory removes bad spirits," the Elephant Monk tells me. He wears the brown robes of a forest monk and chews steadily on betel-infused *maak,* which he spits out in great blood-like wads. He also wears ivory. Around his neck is an ivory elephant-head pendant suspended from ivory prayer beads representing the 108 human passions.

The elephant is a symbol of Thailand and is revered in Buddhism. According to legend, a six-tusked white elephant entered the right side

of Queen Maya the night she became pregnant with Siddhartha Gautama. The Elephant Monk believes he was an elephant in a past life and is well-known among mahouts. He tells me he has 100,000 followers around the world, though during my visit to his temple only a few show up. They kneel before him with offerings and receive an amulet he has blessed.

Many Thais wear amulets, sometimes dozens, to bring them luck and protect them from harm and black magic. Bangkok's amulet market is huge, with countless vendors selling tens of thousands of small talismans made of materials such as metal, compressed dust, bone—and ivory. High-end amulets can fetch $100,000 or more. There are magazines, trade shows, books, and websites devoted to amulet collecting. Amulets hang from the rearview mirror of almost every Thai cab. Ousted Thai leader Thaksin Shinawatra credits his Buddhist amulet with saving him in assassination attempts, and the Thai Army has distributed amulets to its border soldiers to ward off Cambodia's black magic.

**IN ALMOST EVERY SHOP I VISITED IN MANILA SOMEONE PROPOSED A WAY I COULD SMUGGLE IVORY TO THE U.S.**

The Elephant Monk's main income is from amulets, and he offers a strange variety, including images of himself and of the Buddha as well as amulets made with plastic-encased bits of bone from the skulls of dead pregnant women, pure corpse oil, soil from seven cemeteries, tiger fur, elephant skin, and carved ivory. Business is good enough that he's building a new temple, Wat Suanpah, modeled in part after Thailand's popular tiger parks—often front organizations, critics say, for the illegal tiger trade. The Elephant Monk suffered similar controversy when a recent television exposé reported that he'd starved an elephant to death for its skin and ivory, but he says it died of natural causes and he was only holding an elephant funeral. Besides, by shopping in Surin, he tells me, he can find all the elephant ivory and skin he needs. Before the exposé, he took in about one million baht ($32,000) a month from his gift shop, the Internet, and foreign travels. Now he's down to about 300,000 baht a month. But, he says, in just three days in Malaysia or Singapore he could sell his followers one million bahts' worth or more.

Thailand has a small, natural population of Asian elephants, an endangered species long off-limits to international trade. Inside Thailand, however, the rules are less rigid. Mahouts and others may sell the tusk tips of live domesticated elephants and the tusks of ones that died of natural causes. For years international ivory traffickers have capitalized on this, smuggling in African ivory to mix with Asian ivory.

Conservationists refer to this as the "Thai loophole." But there's a far bigger loophole enjoyed by every country in the world. African ivory brought into a country before 1989 may be traded domestically. And so anyone caught with ivory invokes a common refrain: "My ivory is pre-ban." Since no inventory was ever made of global ivory stocks before the ban, and since ivory lasts more or less forever, this "pre-ban" loophole is a timeless defense.

Thailand's ivory market has been evolving. "Ivory traders are stockpiling," says Steve Galster, director of the Freeland Foundation, a Bangkok-based nongovernmental organization (NGO). "Since CITES has a history of relaxing trade bans, they feel it's a safe gamble."

Thailand, like the Philippines, has another commodity traffickers value: corruption. A ton of seized African ivory disappeared recently from a Thai customs warehouse. When I ask to see the rest, customs officers refuse and suggest that journalists stole it. Only when I say I heard otherwise am I told the truth: Customs officers are believed to have been the culprits. Corruption is

To keep the ivory from the black market, a plainclothes ranger hacks the tusks off a bull elephant killed illegally in Kenya's Amboseli National Park. In the first half of this year six park rangers died protecting Kenya's elephants; meanwhile, rangers killed 23 poachers.

中 国
中央电视台

A Chinese reporter in Kenya covers the 2011 burning of 5.5 tons of smuggled ivory. Kenya helped launch a global ivory ban in 1989 but lately has been stockpiling its ivory. The ivory here belonged to other countries.

so bad in the Philippines that in 2006 the wildlife department sued senior customs officers for "losing" several tons of seized ivory. Chastened, the customs office turned its next big ivory seizure over to the wildlife department, which soon discovered that its own storeroom had been raided. Piles of tusks had been replaced with exact duplicates made of plastic.

The Elephant Monk's favorite carver, Jom, lives on a dirt road in a place so remote that I blink when I realize that the vegetable stands in front of Jom's house are actually glass jewelry cases filled with ivory Buddhist figurines. On the outside of one case is a bumper sticker bearing the Elephant Monk's face. Most of the ivory is Thai. "That is African," the Elephant Monk says, pointing to a piece that's especially white.

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Because this is about faith, and because faith requires suspension of disbelief, ivory traded for religious purposes doesn't garner the aggressive scrutiny it might if it were carved into, say, chess pieces. God's ivory has its own loophole.

## CHINA'S IVORY FACTORIES

Inside the Beijing Ivory Carving Factory it smells and sounds like what it essentially is: a vast dentist's office. The whir of electric drills on tusks fills the air. Ivory dust lies heavy on windowpanes and doorframes and even coats my teeth as I make my way among men and women bent over images that repeat the religious and mythological motifs I find throughout China, such as Fu, Lu, and Shou, the gods of luck, money, and long life; the Happy Buddha; and Guanyin, Buddhist goddess of mercy, a Madonna-like figure who doubles as a fertility goddess and who sometimes holds in her arms a male child, the "giving sons" Guanyin, popular under China's one-child policy. No matter where I find ivory, religion is close at hand. "Chinese people believe in the concepts these figures represent," the head of the Daxin Ivory Carving Factory in Guangzhou tells me.

At the time of the ivory ban, Americans, Europeans, and Japanese consumed 80 percent of the world's carved ivory. Today in the heart of Beijing, dealerships offering Maseratis, Bentleys, and Ferraris rub shoulders with Gucci and Prada. Nearby is the Beijing Arts and Crafts Emporium, whose first-floor ATM dispenses 24-karat gold bars. Up the escalator, past galleries of jade and silk, the main ivory boutique sparkles like a snow-covered Tiffany's. One of the first items I notice is a carved ivory Guanyin behind glass with so many zeros on its price tag I have to ask for help—1360000.00 (about $215,000).

By all accounts, China is the world's greatest villain when it comes to smuggled ivory. In recent years China has been implicated in more large-scale ivory seizures than any other non-African country. For the first time in generations many Chinese can afford to reach forward into a wealthy future, and they can also afford to look back into their own vibrant past. One of the first places many look is religion.

"We don't all only think of money," Xue Ping corrects me as we sip tea in his Buddhist art gallery inside the Grand Hotel Beijing. During a 2007 pilgrimage retracing the Buddha's life from Nepal to India, the advertising executive had a vision: The Buddha challenged him to do good with his life. He returned home and in 2009 founded a company he called Da Cheng Bai Yi (transmitting great heritage), dedicated to supporting China's great masters in five art forms: lacquer, lacquer carving, porcelain, thangka scrolls, and ivory carving. Xue tracked down 62-year-old Li Chunke, one of only about 12 national master ivory carvers in China. Xue built Li an ivory-carving studio in Beijing's arts district, rented him an apartment, and opened

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**MANY THAIS WEAR IVORY AMULETS TO BRING THEM LUCK AND PROTECT THEM FROM HARM AND BLACK MAGIC.**

Just as some Filipino priests baptize ivory images, Buddhist monks perform a ceremony called *kai guang,* the opening of light, to consecrate religious icons. "Ivory is very precious," Xue tells me, "so to be respectful of the Buddha one should use precious material. If not ivory then gold. But ivory is more precious." It is a version of the same message I heard from Filipino Catholics: Ivory honors God.

In every shop and factory I visit in China, a substantial portion of the inventory consists of religious carvings, including many of the most valuable pieces. Among the high-end buyers are military officers—surprisingly well paid in China—who give ivory to superior officers and companies that give carvings to other businesses and government regulators to influence them. "We call it the back door," a representative of the government's China Arts and Crafts Association (CACA) explained. And so ivory is used the way a bottle of Johnnie Walker Blue might once have been, except that if the gift works, then ivory blesses its giver as well as its recipient.

At a gallery in Guangzhou, Gary Zeng shows me a photo of a 26-layer "devil's work" ball on his iPhone. The 42-year-old Zeng has just bought two of these ivory balls from the Daxin Ivory Carving Factory, one for himself and one on behalf of an entrepreneur friend. He's come to this retail store to see whether he got his money's worth. I climb into his new Mercedes, drive to his double-gated community, and watch as he hands the less expensive ball to his three-year-old for *National Geographic*'s Brent Stirton to photograph. It will become a centerpiece in a new home Zeng is building, to "hold the house against devils," but for a moment the $50,000 ball is simply a very precious toy. I ask Zeng why young entrepreneurs like him are buying ivory.

"Value," he replies. "And art."

"Do you think about the elephant?" I ask.

"Not at all," he says.

On the corner of one of the most popular ivory-selling streets in China, outside the Hualin International Buddhist jewelry arcade, a four-story electronic billboard runs a video announcing to passersby a hot new investment opportunity: Sales of Buddhist jewelry and related religious products have reached $15.8 billion a year and are growing by 50 percent a year. "There are nearly 200 million Buddhism believers in China," the sign declares. Inside the building two stores deal exclusively in ivory carvings. Down the street other galleries offer Buddhist ivory carvings—some legal, some not.

Everything about China's ivory industry is poised for growth. The government has licensed at least 35 carving factories and 130 ivory retail outlets and sponsors ivory carving at schools like the Beijing University of Technology. Most telling of all, as in the Philippines, Chinese carvers such as Master Li are training their relatives—they're investing in their own blood.

### THE JAPAN EXPERIMENT

In 1989, after ten years during which at least one elephant died every ten minutes, President George H. W. Bush unilaterally banned ivory imports, Kenya burned its 13 tons of ivory stocks, and CITES announced the global

so bad in the Philippines that in 2006 the wildlife department sued senior customs officers for "losing" several tons of seized ivory. Chastened, the customs office turned its next big ivory seizure over to the wildlife department, which soon discovered that its own storeroom had been raided. Piles of tusks had been replaced with exact duplicates made of plastic.

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**MANY THAIS WEAR IVORY AMULETS TO BRING THEM LUCK AND PROTECT THEM FROM HARM AND BLACK MAGIC.**

Just as some Filipino priests baptize ivory images, Buddhist monks perform a ceremony called *kai guang*, the opening of light, to consecrate religious icons. "Ivory is very precious," Xue tells me, "so to be respectful of the Buddha one should use precious material. If not ivory then gold. But ivory is more precious." It is a version of the same message I heard from Filipino Catholics: Ivory honors God.

In every shop and factory I visit in China, a substantial portion of the inventory consists of religious carvings, including many of the most valuable pieces. Among the high-end buyers are military officers—surprisingly well paid in China—who give ivory to superior officers and companies that give carvings to other businesses and government regulators to influence them. "We call it the back door," a representative of the government's China Arts and Crafts Association (CACA) explained. And so ivory is used the way a bottle of Johnnie Walker Blue might once have been, except that if the gift works, then ivory blesses its giver as well as its recipient.

At a gallery in Guangzhou, Gary Zeng shows me a photo of a 26-layer "devil's work" ball on his iPhone. The 42-year-old Zeng has just bought two of these ivory balls from the Daxin Ivory Carving Factory, one for himself and one on behalf of an entrepreneur friend. He's come to this retail store to see whether he got his money's worth. I climb into his new Mercedes, drive to his double-gated community, and watch as he hands the less expensive ball to his three-year-old for *National Geographic*'s Brent Stirton to photograph. It will become a centerpiece in a new home Zeng is building, to "hold the house against devils," but for a moment the $50,000 ball is simply a very precious toy. I ask Zeng why young entrepreneurs like him are buying ivory.

"Value," he replies. "And art."

"Do you think about the elephant?" I ask.

"Not at all," he says.

On the corner of one of the most popular ivory-selling streets in China, outside the Hualin International Buddhist jewelry arcade, a four-story electronic billboard runs a video announcing to passersby a hot new investment opportunity: Sales of Buddhist jewelry and related religious products have reached $15.8 billion a year and are growing by 50 percent a year. "There are nearly 200 million Buddhism believers in China," the sign declares. Inside the building two stores deal exclusively in ivory carvings. Down the street other galleries offer Buddhist ivory carvings—some legal, some not.

Everything about China's ivory industry is poised for growth. The government has licensed at least 35 carving factories and 130 ivory retail outlets and sponsors ivory carving at schools like the Beijing University of Technology. Most telling of all, as in the Philippines, Chinese carvers such as Master Li are training their relatives—they're investing in their own blood.

### THE JAPAN EXPERIMENT

In 1989, after ten years during which at least one elephant died every ten minutes, President George H. W. Bush unilaterally banned ivory imports, Kenya burned its 13 tons of ivory stocks, and CITES announced the global

ivory ban, which began in 1990. Not all countries agreed to the ban. Zimbabwe, Botswana, Namibia, Zambia, and Malawi entered "reservations," exempting them from it on the grounds that their elephant populations were healthy enough to support trade. In 1997 CITES held its main meeting in Harare, Zimbabwe, where President Robert Mugabe declared that elephants took up a lot of space and drank a lot of water. They'd have to pay for their room and board with their ivory. Zimbabwe, Botswana, and Namibia made CITES an offer: They would honor the ivory ban if they were allowed to sell ivory from elephants that had been culled or had died of natural causes.

CITES agreed to a compromise, authorizing a one-time-only "experimental sale" by the three countries to a single purchaser, Japan. In 1999 Japan bought 55 tons of ivory for five million dollars. Almost immediately Japan said it wanted more, and soon China would want legal ivory too. If Kenya's Daniel arap Moi is the father of the ivory ban, then Zimbabwe's Robert Mugabe is the father of its first rupture.

Before it would allow another ivory sale, CITES demanded the results of the Japan experiment: Had the sale increased crime? Specifically, had elephant poaching or ivory smuggling gone up? To find out, it launched one program to count illegally killed elephants and another to measure ivory smuggling. For a science-based organization, it was an odd way to conduct an experiment. CITES had approved the sale and had then set about constructing a way to gauge its impact, which is a bit like pushing the button to test the first atomic bomb and then building a device to measure the explosion.

It's easy to kill an elephant (lately poachers in Kenya and Tanzania have been using poisoned watermelons), but it's hard to locate dead bodies, and it's taken CITES years to get the counting program running. CITES officials refuse to issue a formal estimate of the elephants killed annually for fear that any number, which would derive from 2007 population estimates and limited 2012 poaching data, will "become embedded as hard truth in the public psyche." Still, according to Kenneth Burnham, official statistician for the CITES program to monitor illegally killed elephants, it is "highly likely" that poachers killed at least 25,000 African elephants in 2011. The true figure may even be double that. Meanwhile, last year saw an estimated 34.7 tons of illegal ivory seized globally. Using an Interpol rule of thumb that says seized contraband equals 10 percent of actual smuggling, and assuming that each elephant carries 22 pounds of ivory, that weight equates to 31,500 dead elephants. "The point is this," says Iain Douglas-Hamilton of Save the Elephants, "tens of thousands of elephants were killed last year. And the figures are going up drastically."

Quantifying the illegal ivory trade is difficult too. Smugglers don't file sales reports. To estimate smuggling activity, CITES uses ivory seizures as a proxy. Even as a proxy, seizures are tricky. They accurately tell you only the bare minimum of illegal activity going on in a country, and there's a lot they can't tell you. More ivory seizures in one year can mean that smuggling has increased, or that law enforcement is working harder, or both. Fewer seizures can mean what you might hope, but they can also mean that law enforcement is on the take. Big-time smugglers have connections in local wildlife departments, customs offices, and freight-forwarding and transportation companies that enable them to move multi-ton shipments from one country to another. (In the Philippines, for example, ivory traders I met accused customs officers of seizing illegal ivory only when someone hadn't made a payoff.) Worst of all, a seizures-based system rewards countries for confiscating ivory, when what they really need to do is follow smuggled ivory up the demand chain to the kingpins, a reason good investigators consider seizures to be bad law enforcement.

To audit ivory seizures, CITES engaged Traffic, an NGO that monitors global wildlife trade. Traffic is not an independent auditor, however. It is a subsidiary of the World Wildlife Fund (WWF) and of the International Union for Conservation of Nature (IUCN), which, like many NGOs, have research projects and offices

in ivory-trafficking countries, complicating Traffic's ability to render independent judgments. Traffic based its new ivory-seizures monitoring program, the Elephant Trade Information System (ETIS), in Africa's leading pro-ivory-trade country, Zimbabwe.

From the beginning, Traffic boasted that its ETIS database extended back to the 1989 ivory ban, but countries were not asked to report ivory seizures to ETIS until 1998. For a decade its data came from random Traffic surveys, and it had scant data on seizures by key countries, such as Japan (20 cases in a decade), Thailand (21 cases), the Philippines (5 cases), and China (2 cases). Even after ETIS was up and running, many governments rarely bothered to report their seizures, so when it was time to judge the Japan experiment, Traffic's database was heavy on cases from the U.S. and European Union (more than 60 percent) and light on cases from where it mattered: Asia (less than 10 percent). ETIS had no good baseline to judge the effects of the Japan sale.

**IN 1997 ZIMBABWE'S PRESIDENT DECLARED THAT ELEPHANTS MUST PAY FOR THEIR ROOM AND BOARD WITH THEIR IVORY.**

CITES might have taken a holistic approach to the Japan experiment, combining reports of international NGOs, whose undercover investigators found an increase in illegal ivory trade after the Japan sale, with data from Traffic, whose ETIS statistics did not show a definite correlation between the Japan sale and seizures. It might have recognized the limitations of ETIS—whose core metric, seizures, is, after all, controlled by the countries being evaluated. Since CITES also had problems calculating how much elephant poaching was going on, it might have declared the Japan experiment inconclusive, or even a failure.

A failure is what China considered it. In a 2002 report China warned CITES that a main reason for China's growing ivory-smuggling problem was the Japan experiment: "Many Chinese people misunderstand the decision and believe that the international trade in ivory has been resumed." Chinese consumers thought it was OK to buy ivory again.

CITES ignored China's warning and placed its faith entirely in the ETIS statistics. "The data we have from ETIS is that there is no correlation between decisions made at CITES and the illegal trade," Willem Wijnstekers, CITES secretary-general, would later assert in anticipation of more CITES-approved ivory sales. Tom Milliken, director of ETIS, would likewise suggest that the Japan sale had worked: "It is encouraging to note that the illicit trade in ivory progressively declined over the next five years." But Milliken didn't know what the illicit trade had done; what he knew was his seizure statistics. Nevertheless a judgment was made, and the future of the African elephant may forever be clouded by the moment when CITES, lacking the data to evaluate the impact of its first ivory sale, endorsed a second.

By 2004 China had forgotten its concerns and petitioned CITES to buy ivory. In March 2005 CITES sent a team of three people, including Milliken, to China for five days to evaluate its ivory-control system. The team returned "more than satisfied" and predicted that China's system could "eradicate, or at least significantly reduce, illicit trade." They also noted, however, that two successive ETIS reports had found that China was the single most important reason the illegal ivory trade was increasing. The CITES secretariat therefore refused China's request to buy ivory.

But ETIS could be manipulated. It scored countries not only on ivory seizures weight but also on law enforcement. It was possible to game the ETIS system by reporting lots of small seizure cases, such as a tourist wearing

Some two million Catholics join a yearly procession celebrating the Santo Niño de Cebu (Holy Child of Cebu). Seen here is the Mother Mary image, Our Lady of Consolation, with ivory head and hands. On Cebu the word for ivory also means "religious statue."

A cemetery for privately owned elephants in Surin, Thailand, shows deep devotion. Thailand allows internal trading of ivory from domesticated Asian elephants, and smuggled African ivory finds its way into the mix.

ivory earrings. "Tom Milliken told me to make raids on Chatuchak [a Bangkok market] to get my cases up," a frustrated Thai official told me. In 1999, the year of the Japan sale, China had reported seven ivory seizures to ETIS. Soon after it petitioned CITES, China was reporting dozens of cases a year to ETIS, most the personal effects of tourists. Recently it has been reporting hundreds of cases a year. This past February China made public one of its big ivory-enforcement efforts of 2011, involving 4,497 personnel and 1,094 vehicles and leading to 19 cases. It had resulted in the confiscation of 63.5 pounds of ivory, the weight of an overfed poodle.

In July 2008 the CITES secretariat endorsed China's request to buy ivory, a decision supported by Traffic and WWF. Member countries agreed, and that fall Botswana, Namibia, South Africa, and Zimbabwe held auctions at which they collectively sold more than 115 tons of ivory to Chinese and Japanese traders.

As a test for whether ivory sales increase crime, the Japan experiment was flawed. As a prognosticator for China, it had deeper problems. Japan is an island nation with a narrow primary use for its ivory: signature stamps called *hanko*. China shares borders with 14 countries; it has a vast coastline, a booming economy, ten times the population, a separate system for ivory-loving Hong Kong, extensive investment in Africa, and uses for ivory ranging from sculptures to cell phone covers. After Japan bought ivory, China said its smuggling problem went up. Now China itself was entering the ivory business. CITES urged the world not to worry.

## DEVILS LURK IN DETAILS

Meng Xianlin is executive director general of China's CITES management authority, making him China's top wildlife-trade official. He attended the 2008 ivory auctions in southern Africa. Over sheep tripe and noodles near his Beijing office, he shares a startling secret with me: The African auctions had not been competitive. Before they left for Africa, the Japanese team of buyers flew to Beijing, where they made a strategic suggestion. Since Japanese use primarily medium-size, high-quality tusks for hanko and Chinese prefer either large, whole tusks for big sculptures or small pieces for decorative touches, the Japanese proposed that each country bid on separate types of ivory and keep all the prices low. The prices they paid were so low, Meng tells me, that an official from Namibia, which had held the first auction, followed the Asian delegations from country to country hoping for evidence her country had been cheated.

Still, to the CITES secretariat, the auctions had been a success. They'd raised $15.5 million, most of which was supposed to go to African conservation projects. And while an average price of only about $67 a pound for the ivory meant that the Africans had less to spend on conservation, it also meant, according to CITES, that China could now do its part for law enforcement by flooding its domestic market with the low-priced, legal ivory. This would drive out illegal traders, who CITES had heard were paying up to $386 for a pound of ivory. Lower prices, CITES's Willem Wijnstekers told Reuters, could help curb poaching.

Instead the Chinese government did the unexpected. It raised ivory prices. Through an affiliate of its craft association, CACA, the government charged entrepreneur Xue Ping $500 a pound, a markup of 650 percent, and imposed fees on the Beijing Ivory Carving Factory that brought the company's costs to $530 a pound for Grade A ivory. China also devised a ten-year plan to limit supply and is releasing about five tons into its market annually. The Chinese government, which controls who may sell ivory in China, wasn't undercutting the black market—it was using its monopoly power to outperform the black market.

Applying the secretariat's logic that low prices and high volumes chase out smugglers, China's high prices and restricted volumes would now draw them in. The decision to allow China to buy ivory has indeed sparked more ivory trafficking, according to international watchdog groups and traders I met in China and Hong Kong.

And prices continue to rise. According to Feng You Min, sales director at the Daxin Ivory

Carving Factory, the price of raw ivory has risen to 20 times the price paid in Africa. The genie cannot be returned to her bottle: The 2008 legal ivory will forever shelter smuggled ivory.

There is one final flaw in the CITES decision to let China buy ivory. To win approval, China instituted a variety of safeguards, most notably that any ivory carving larger than a trinket must have a photo ID card. But criminals have turned the ID-card system into a smuggling tool. In the

**BY ALL ACCOUNTS, CHINA IS THE WORLD'S GREATEST VILLAIN WHEN IT COMES TO SMUGGLED IVORY.**

ID cards' tiny photographs, carvings with similar religious and traditional motifs all look alike. A recent report by the International Fund for Animal Welfare found that ivory dealers in China are selling ivory carvings but retaining their ID cards to legitimize carvings made from smuggled ivory. The cards themselves now have value and are tradable in a secondary market. China's ID-card system, which gives a whiff of legitimacy to an illegal icon, is worse than no system at all.

Just before elephants were discussed at an August 2011 CITES meeting, China orchestrated the expulsion of all attending NGOs. It was an extraordinary act. Among those expelled were representatives of the Born Free Foundation, the Humane Society International, the Japan Federation of Ivory Arts and Crafts Associations, the Pew Charitable Trust, Safari Club International, and me (for the National Geographic Society). Traffic's Tom Milliken was allowed to remain to deliver his latest ETIS results. The reason for the expulsion, Meng tells me, was a report by a small but influential London-based NGO, the Environmental Investigation Agency (EIA), which had sent undercover Chinese operatives into China. EIA alleged that China's ivory-control system was a failure, that up to 90 percent of the ivory on the Chinese market was illegal, and that the 2008 auctions had resurrected the illegal ivory trade. Meng was outraged. Yes, he said, 80 percent of EIA's report was true, "but they should have come to us first."

Last year CITES made a startling admission: "The Secretariat continues to struggle to understand many aspects of the illegal trade in ivory." This past April, Tom Milliken confessed something to the BBC that was eerily reminiscent of China's warning after the Japan experiment: "Did allowance of legal ivory to go into China exacerbate a situation? One could probably argue now, with hindsight, that indeed it did. It created perhaps an image in the minds of many potential Chinese consumers that it was OK to buy ivory."

Meng chuckles as I pour him another bottle of beer. He tells me that after the African ivory arrived in China, a strange sound could be heard coming from one shipment. It took some time to discover the source. During the bidding South Africa's ivory had looked the best and the whitest. Now some tusks were splitting open. "You could hear it cracking," Meng says. To get a good price, he speculates, the South Africans had bleached their ivory white, and now dehydration was causing the tusks to crack.

Even more precious than the savanna elephant's white ivory is the yellow ivory of the smaller, forest elephant. "This is the best," the Daxin Ivory Carving Factory's Feng tells me, holding up a chunk of forest elephant tusk. Carvings made from forest elephant ivory sell out so quickly that customers have been commissioning them. The only carved image he has left to show me is an old one of Chairman Mao with a crack in it. Trouble is, forest elephants don't live in any of the countries where China legally bought ivory. They live in central and western Africa, including in Cameroon, the country raided by Muslim poachers earlier this year.

In March CITES will meet again to discuss the future of the African elephant. □

# *the glory of* leaves

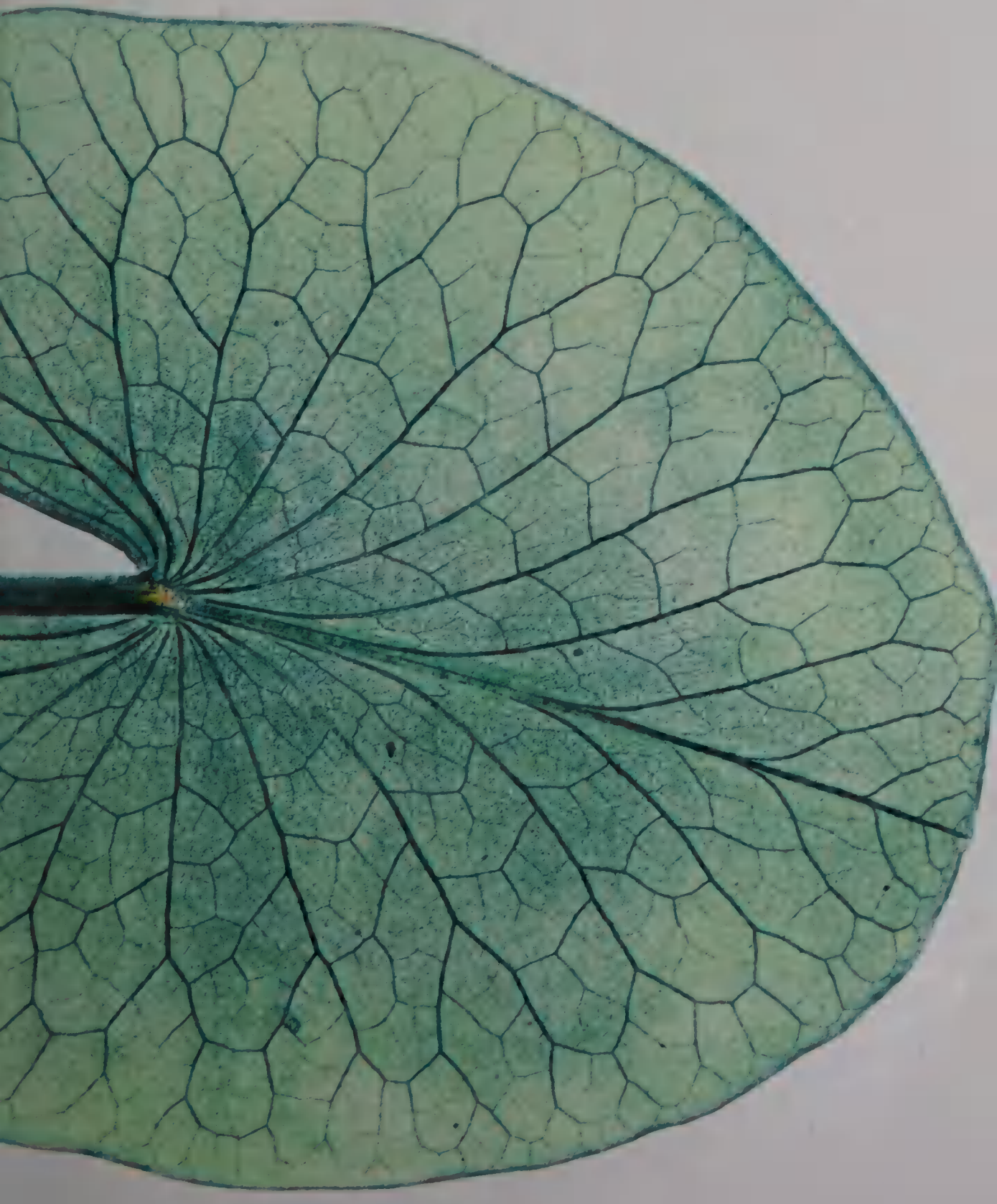
*Sometimes a masterwork hangs in a museum.*
*Other times it hangs from the branch of*
*a tree or rounds out a slender stem.*



PHOTO: CARSTEN PETER. PRIVATE COLLECTION OF PETER HEILMANN

## Water Lily

*Like snorkels, the mouthlike stomata on water lily leaves point up, where they find the air they need.*



*By Rob Dunn*

## We have all held leaves, driven miles to see their fall colors, eaten them, raked them, sought their shade. Since they are everywhere, it's easy to take them for granted.

But even when we do, they continue in their one occupation: turning light into life. When rays of sunlight strike green leaves, wavelengths in the green spectrum bounce back toward our eyes. The rest—the reds, blues, indigos, and violets—are trapped. A leaf is filled with chambers illuminated by gathered light. In these glowing rooms photons bump around, and the leaf captures their energy, turning it into the sugar from which plants, animals, and civilizations are built.

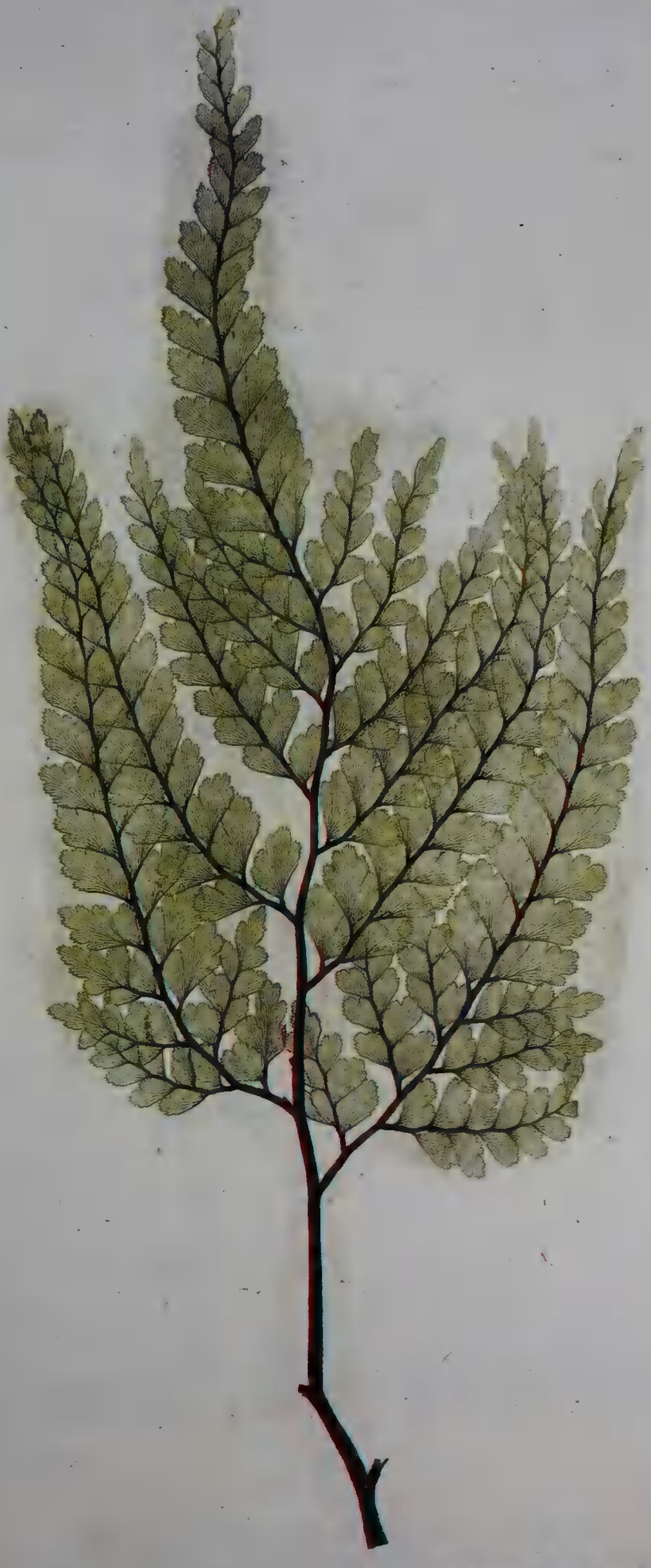
Chloroplasts, fed by sun, water, carbon dioxide, and nutrients, do the leaf's work. They evolved about 1.6 billion years ago when one cell, incapable of using the sun's energy, engulfed another cell—a cyanobacterium—that could. That cyanobacterium became the ancestor of every living chloroplast. Without their chloroplasts plants would be left like the rest of us, to eat what they find. Instead they hold out their green palms and catch light. If there is magic in the world, surely this is it: the descendants of tiny creatures in leaves, capable of ingesting the sun.

If you gather a bouquet of leaves to consider their magic, it is hard to overlook their diversity and, if you are the curious sort, to wonder why there exists such a preponderance of forms. Some leaves don't seem to be leaves at all, having become flower petals, thorns, or the spines on a cactus. But even an ordinary oak leaf, dandelion leaf, and grass blade differ in size, thickness, shape, hue, texture, taste, and nearly every other feature.

Leaves are large, small, thick, thin, compound, simple, curved, or lobed. And these terms just begin to describe the differences botanists have tried to catalog in their rich poetry of obscure adjectives—pinnate, ciliate, barbellate, bearded, canescent, glabrous, glandular, viscid, scurfy, floccose, arachnoid, and my favorite, tomentose (covered with woolly hairs). But putting the variety of structures aside, most leaves do

Fern

*Once, forests were crowned with the waving leaves, or fronds, of ferns. Some modern ferns qualify as trees, but most are smaller plants. Their fronds reach up out of understories—and other realms where living is difficult—to catch some light.*



Direct Autumn Printing
H. Bolton
April 1857

INGHAM ARCHIVES & HERITAGE, U.K.

BRITISH LIBRARY

## Seaweed

*It looks like a plant with its branches reaching out, but this seaweed is in fact a kind of marine alga. Seaweeds evolved independently from plants; the resemblance shows that the streams of evolution often converge.*

WILLIAM HENRY FOX TALBOT, SCIENCE & SOCIETY PICTURE LIBRARY

## Grape

*Blood circulates through human veins without leaving the body.*
*Grapevine leaves are open to the universe. Gases diffuse from veins to the leaf surface,*
*where the exchange of water and carbon dioxide takes place.*

## Leaf Veins

*Arranged in various patterns, veins in leaves may follow paths that range from one simple canal per leaf to parallel systems and branching, high-density networks.*

ART: YANA BEYLINSON
SOURCE: C. KEVIN BOYCE, UNIVERSITY OF CHICAGO

essentially the same thing: They exist in the main to hold chloroplasts aloft. How can so many different geometries all perfectly capture the sun?

The work of natural selection offers a key to the puzzle. Desert leaves tend to be small, thick-skinned, waxy, or spiny, just like leaves in salty regions or other harsh lands—clear examples of the relatively few ways evolution can deal with a lack of water. Rain forest plants often have narrow leaves, with long, thin "drip tips," to drain away excess water. In cold places one finds leaves with teeth—like birches and cherries—though why this particular pattern exists is the subject of debate.

Some of the most extreme examples of the way natural selection shapes leaves can be found at high elevations in the tropics, where nights are consistently cold and damp and the days hot and dry. Scramble high enough above the tree line in the mountains of Africa, Asia, Hawaii, and the Americas, and you will see thick towers of plants crowned by mops of living and dead leaves.

In a poetic moment botanists named these lovely circular leaf arrangements "giant rosettes." The thick living leaves of these rosettes shelter new buds. They're hairy too, which adds insulation. The dead leaves help the plants withstand freezing at night and, simultaneously, save the night's cold dew for the dry day. Remove those decaying leaves from rosettes at high elevations and the plants can freeze to death, naked without their dead-leaf fur.

In many environments natural selection tends to favor a limited number of similar forms again and again, given the genes it has to work with. Sometimes there really does seem to be just one or a few best ways to deal with a particular set of conditions. If rosettes are not convincing, consider the meat-eaters. In nutrient-poor bogs, plants have repeatedly turned to animals to supplement what the soil alone cannot provide. They have evolved rolled leaves, sticky hairs, mucous pools, or snap traps, all for capturing live prey. A bog is a terrifying place to be a fly.

But if climate and nutrient availability were the only explanations for leaf diversity, all of the leaves in a particular environment—a desert, a mountaintop, your backyard—would tend to be the same. Of course they are not. Many of the qualities of the leaves in your yard or salad are due to the limits of genes and time. Not all plants have the genetic variation it takes to become, under the natural selection imposed by desert conditions, a cactus. Conditions change. Species move. Every leaf is a work in progress. One suspects, for example, that leaves are evolving now to deal with the conditions in cities—pollution, drought, intense heat, and animal waste—but it may require more generations for natural selection to stumble, death by death, upon the more successful forms.

Other specific traits may have to do with the battles that have gone on among plants each day for more than 400 million years. Plants fight for nutrients and water in the soil, and they fight for sunlight in the canopy. Competition is why trees grow tall, stems become trunks, and forests grow dense. Trees have evolved in the struggle of plant against plant many times, in vastly different lineages. The highest leaves win, and so

trees tend to evolve to be as tall as possible, given the limits of physics and precipitation. Without competition, every forest would be a thick film of green life.

The battles among plants have changed their stems and their veins. Leaves with more veins can carry more water to the chloroplasts, allowing the chloroplasts to make more sugar and the plants to grow faster. These species in turn can hold their leaves aloft to occupy more space in the sky and consume more sunlight before others get to it. Through time the plants that were able to produce more and more veins in their leaves won many battles and some wars.

Leaves with densely branched patterns of veins are also able to grow more quickly. The veins of a maple leaf, for instance, are like the roads of a city; they go everywhere and often intersect. They traffic in nutrients and water. The maple leaf can quickly get what it needs to continue to feed from the sun. Other leaves are not so lucky. Amid the seething competition for space in tropical forests, pity the single-veined leaf.

Plants have more to cope with than competition from other plants. The evidence of animals eating leaves is almost as ancient as the evidence for leaves themselves. In fossil dinosaur poop one finds evidence of ancient leaves. In fossil leaves one finds the holes made by ancient mouths. Nothing on life's menu is more popular. Moths, butterflies, beetles, fungi, monkeys, sloths, and great loping monsters like cows, bison, and giraffes eat the hard-earned greenery of plants, which, for all of their ingenuity, have never figured out how to run away.

So leaves resort to self-defense. Some plant leaves have become specialists in deadly tricks. Grass blades evolved the ability to accumulate the silica from the soil—becoming like tiny glass slivers, which ruin the teeth of browsers like cows one bite at a time. Other plants use chemicals to make themselves unpalatable or even poisonous. Sometimes the weapons are visible: latex oozing out of a vein or tingly hairs projecting from leaf blades. Other times they lurk unseen, waiting for the unsuspecting victim, be it the larva of a moth or an undiscriminating sheep.

Climate, competition, defense—these evolutionary saws and scissors can explain much of the diversity of leaves. Yet if you pick up two leaves in your backyard, most of what differs between them—the details naturalists have spent thousands of years naming—remains unaccounted for. Evolution can whittle similar forms again and again when confronted with similar circumstances. But through innovation and chance, evolution can also work in the abstract: Jackson Pollock dashing paint on the canvas of life. We should not expect to understand every tomentose blade or arachnoid lobe. Sometimes it is enough to step back and know a masterwork when we see one, whether it hangs in a museum or from its petiole on the branch of a park tree. Not that leaves care whether you notice; the blessing they convey comes each day with the rise of the edible sun. □

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*Rob Dunn's most recent book is* The Wild Life of Our Bodies. *Illustrations are from* Impressions of Nature: A History of Nature Printing, *by Roderick Cave.*

MARCELLIN BONNET, *FACIES PLANTARUM*, CARCASSONNE MUNICIPAL LIBRARY, FRANCE

## Thistle

*Life is not easy for a thistle. It grows low, where the big heads and mouths of cows, sheep, and other grazers bow. It resists with spines. These spines are not foolproof. Sometimes thistles get eaten or, in the case of this specimen, picked.*

To celebrate Carnival, the city's elite socialize at a masquerade ball in a grand old hotel.

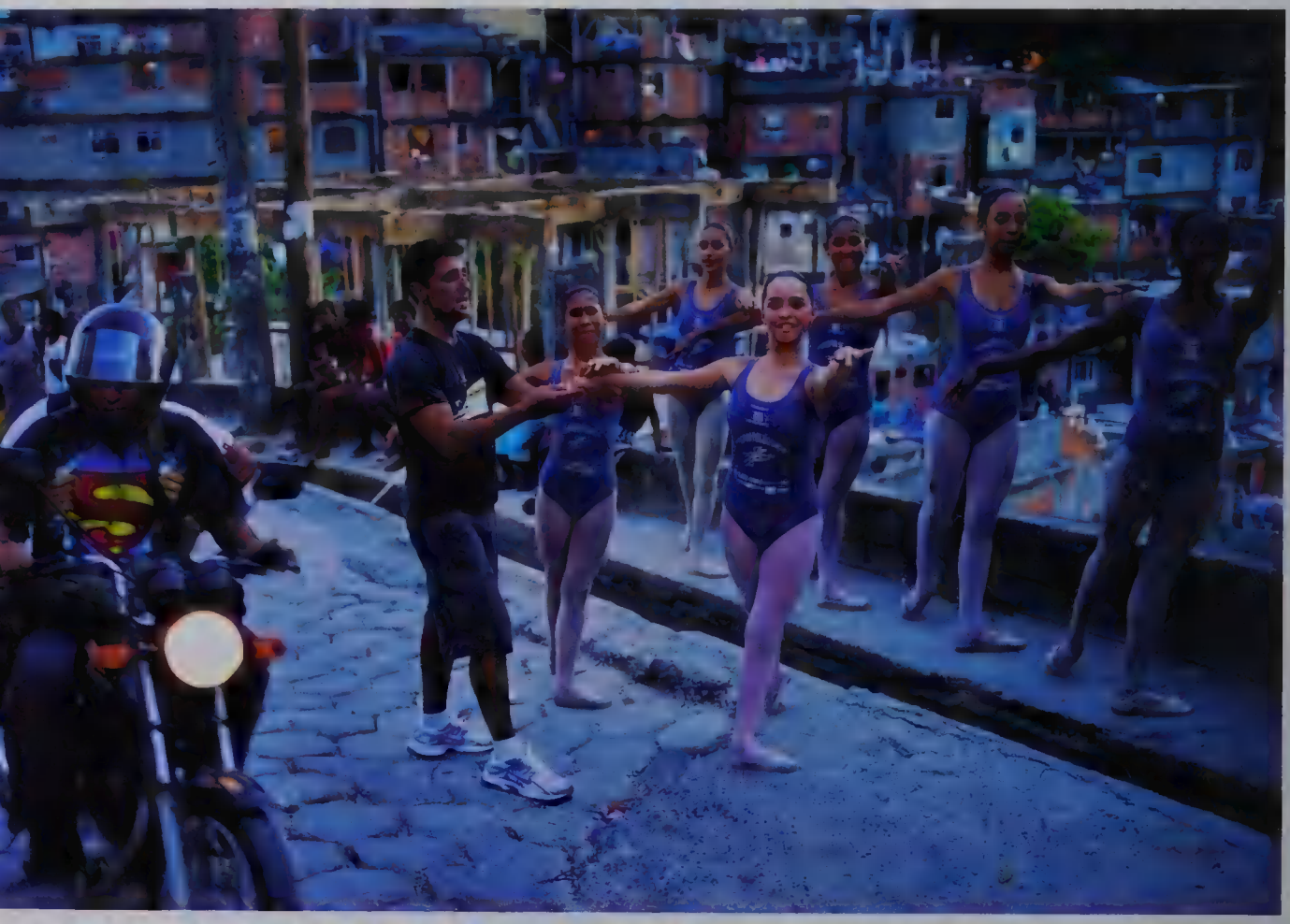
# playing RIO

*Rio is a city of glamour and glitz—but also of poverty and violence in the favelas that climb its hills. With the Olympics coming in 2016, the slums are getting a face-lift.*

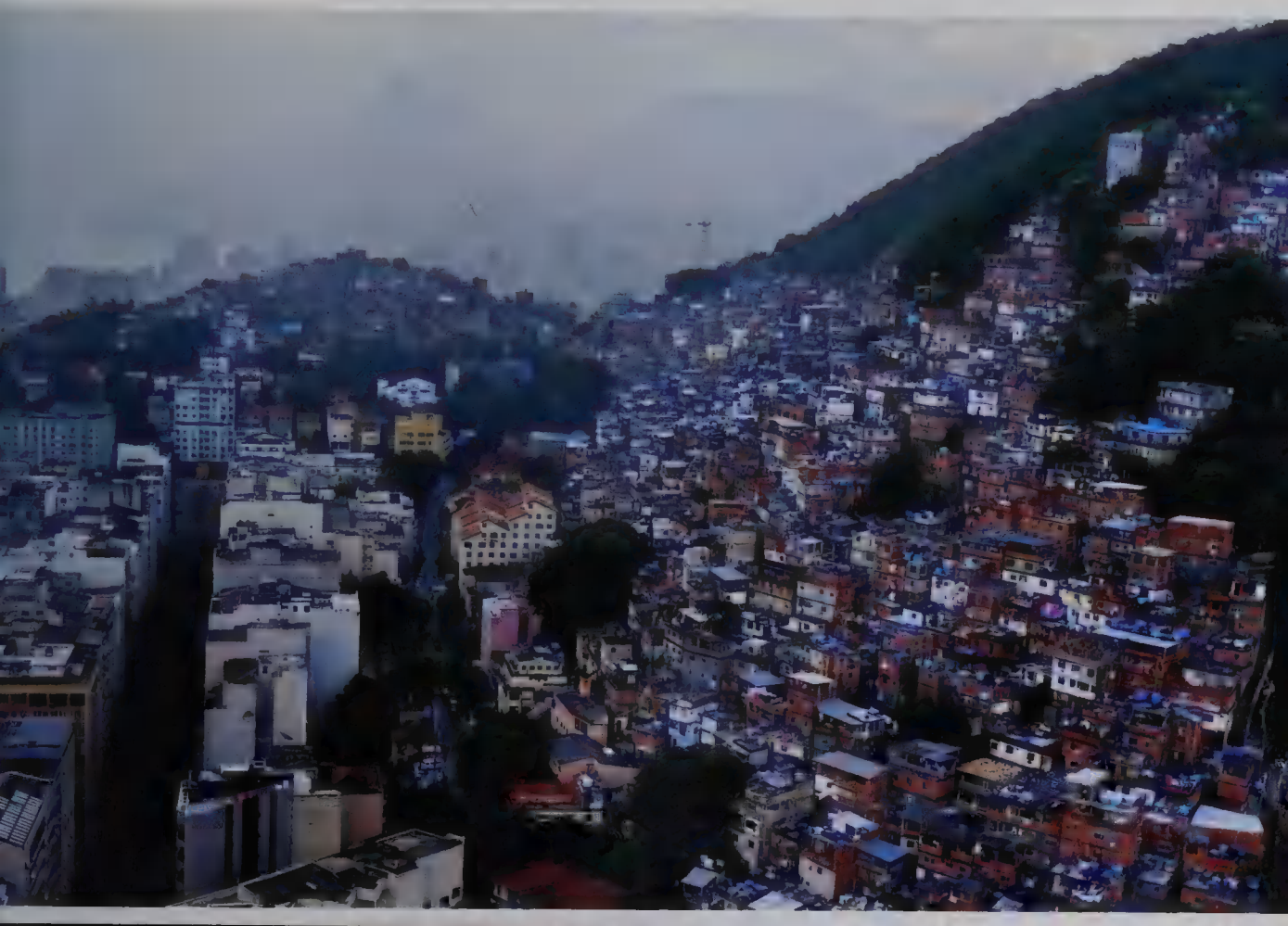
Photographs by David Alan Harvey

On sunny days a million people with their sea of umbrellas may crowd Rio's beaches.

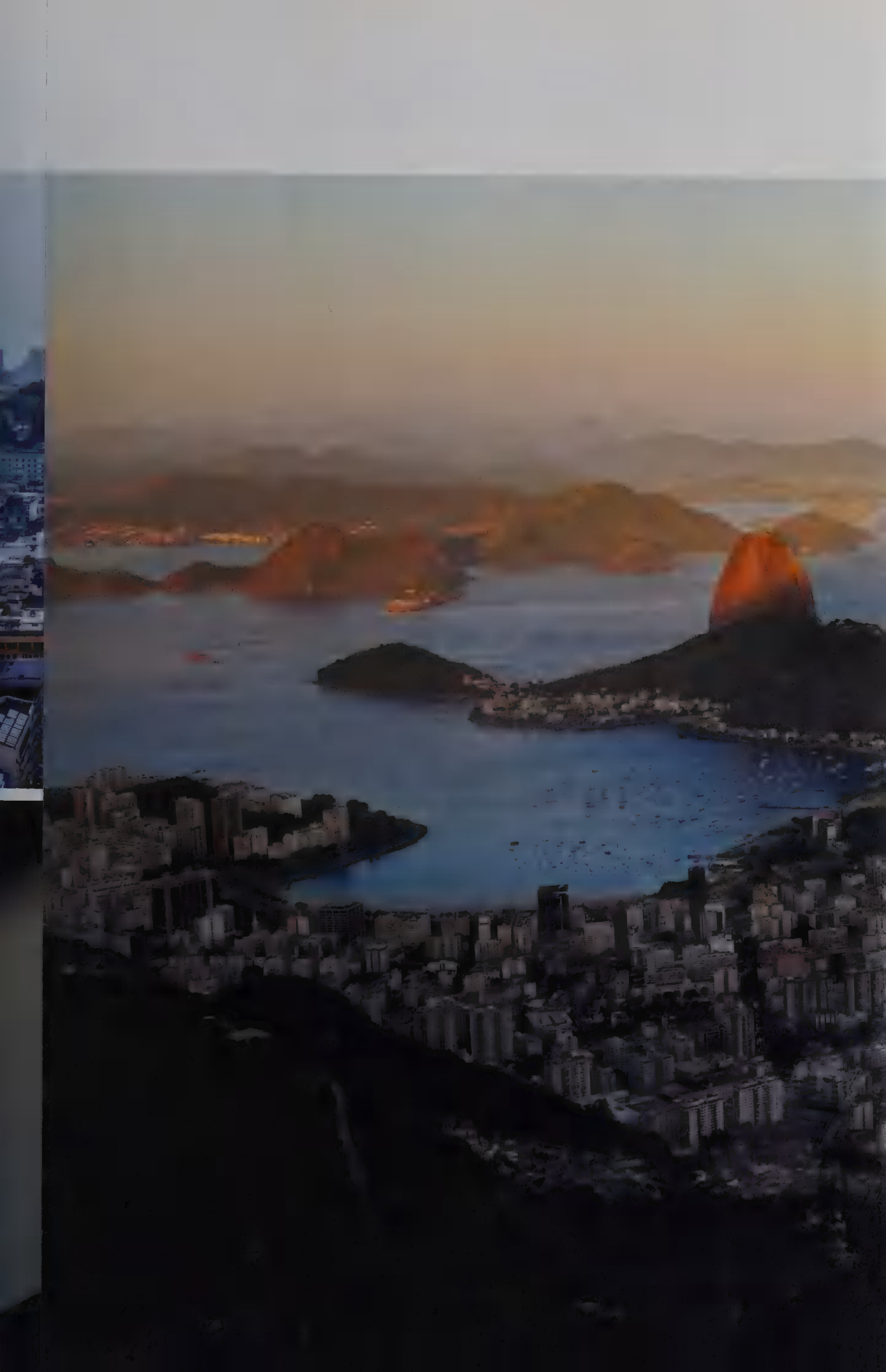
Ballet students strike a pose outside their school in the Cantagalo favela (top). Tickets to the Carnival parades are expensive, so neighbors often gather curbside to watch for free on TV.

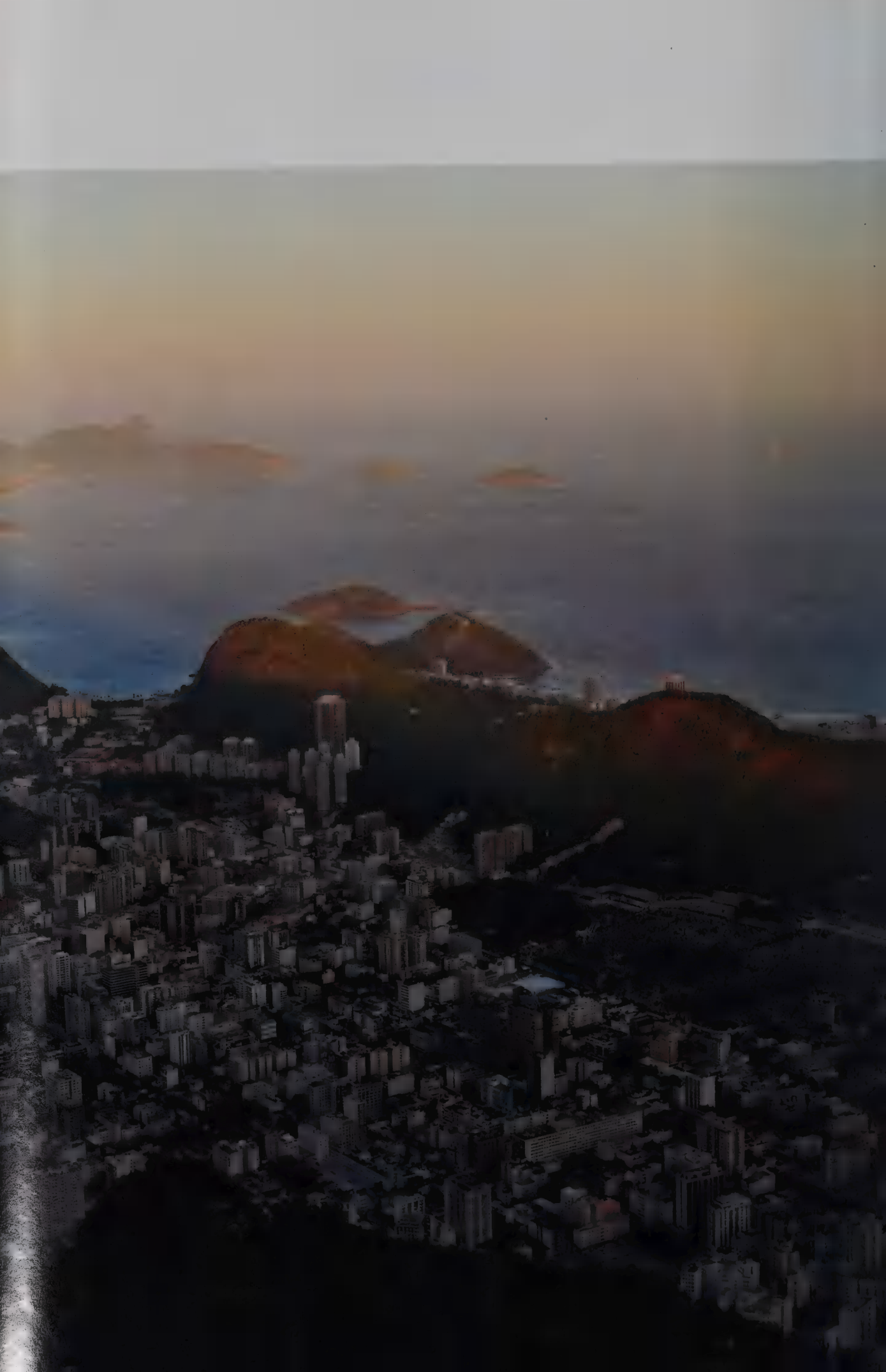


The stacked houses of a hillside favela overlook a neighborhood near the ocean (top). A Carnival dancer's white shirt and blue hatband represent the colors of his samba school.



Finishing her errands, a favela resident passes military police taking part in a training exercise (top). A trolley now idled for repairs normally services the historic area of Santa Teresa.





The landmark 125-foot-tall statue of Christ the Redeemer rises over bays and beaches from the peak of Corcovado, in a panorama made from two images stitched together.

Roving vendors in Copacabana sell everything under the sun, including whimsical trinkets (top). At Carnival, ticket holders fill the Sambadrome to watch a parade that lasts until dawn.

Yachts bob in Botafogo Bay, cradled between the beach and the tall rock known as Sugar Loaf (top). Romance sizzles during Carnival season, when revelers fill the city.

A rock band plays oldies at a Copacabana bar (top). Local TV actors kick back at an Ipanema hotel also favored by international celebrities like Beyoncé and Madonna.

By Antonio Regalado

"We are guinea pigs," declares Fabio do Amaral, a drug-gang killer turned evangelical minister. Brother Fabio preaches at a church in Santa Marta, one of Rio de Janeiro's favelas. What he means is that the citizenry of Santa Marta is part of a plan to clean up the hillside slums for the 2016 Olympics.

The experiment was set in motion in November 2008, when special operations police invaded the slum, a collection of brick and cinder block houses rising like a rickety skyscraper threaded with footpaths ascending 788 steps along a steep incline below the famed Christ the Redeemer statue. Unlike your usual Rio police assault on favela drug dealers—a bloody hit-and-run using armored trucks known as "big skulls"—a contingent of 112 "pacification officers" arrived in Santa Marta that December and stayed to restore order and evict the gang. Then the government built brightly colored apartment blocks and installed new electrical service along with 700 free refrigerators. These days, the place is overrun by film crews and such red carpet visitors as Madonna and John McCain. (Many Brazilian tourists visit too, often entering a favela for the first time.)

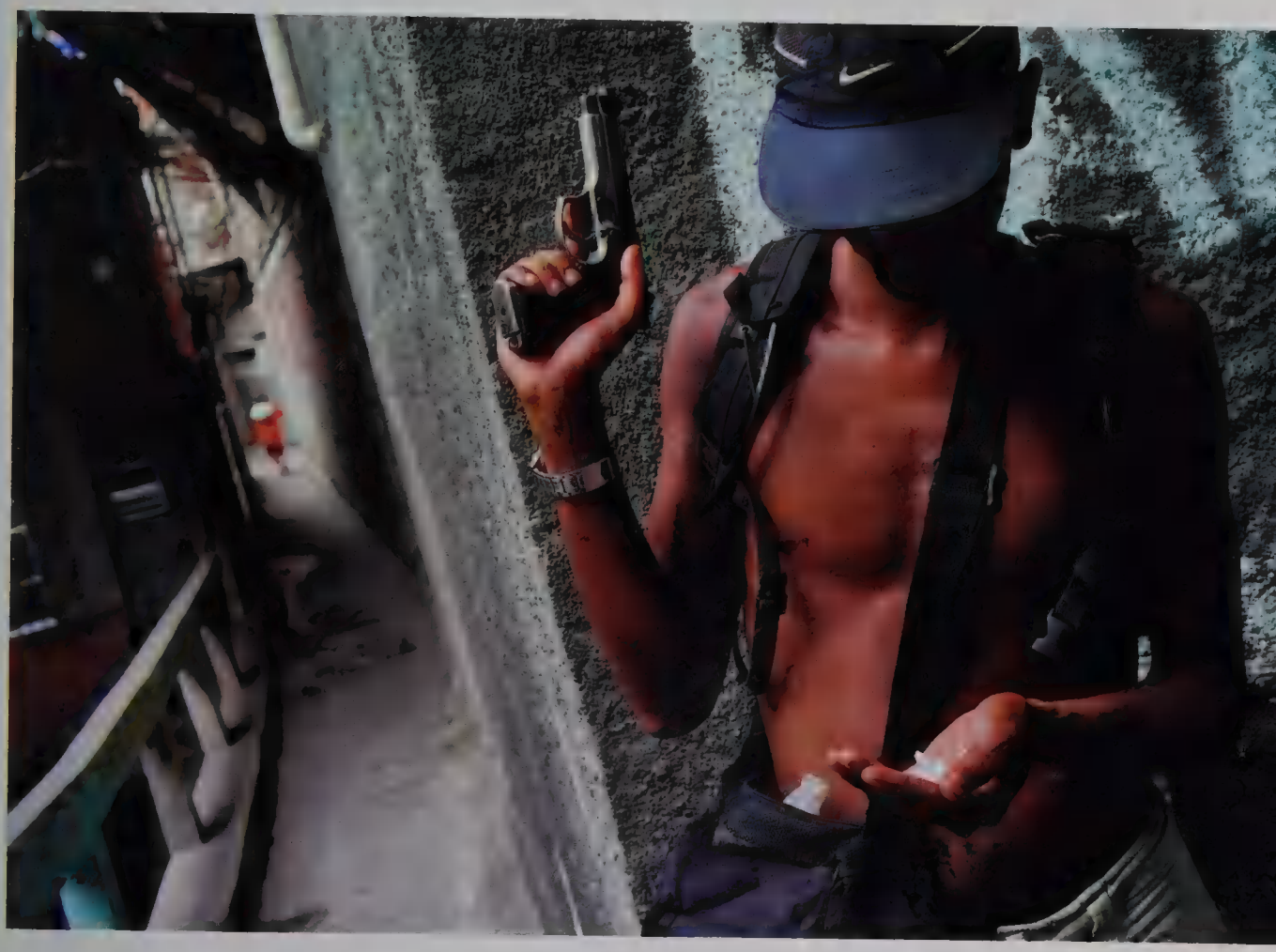
Brother Fabio used to be part of the problem. Born in the slum in 1973, he grew up to be a hit man with the nickname "Bananeira" because he reminded people of a banana tree, walking the favela steps on his hands with his feet splayed in the air. He found faith with the help of a local nun, but full reform didn't happen overnight. "I believe in gradual repentance," says Fabio, flashing white teeth as he restrains two pit bulls that live on his roof. He looks like Mike Tyson dressed in church clothes: a short-sleeved yellow shirt and black nylon dress pants.

When he's not preaching, Fabio chases down men with flip-flops and cracked toes to sign them up for construction-worker training classes. That's a big step for people who, in Rio terms, were *lixo*, human garbage. Now companies aren't afraid to hire them. There's more respect. But it's still not luxurious living. Signs at Santa Marta's entrance warn of dengue, and "high up there it's only sorrows," says Fabio, pointing to the shanties on the hill, beyond the reach of social programs, where some still cook outside on open fires.

RIO NEEDED THE SOLUTION to an economic puzzle involving low wages, poor public transport, a weak state, and income distribution about as fair as a tin-pot kleptocracy's. "It happens in the whole world, but I would say here the dose was greater," says José Mariano Beltrame, state secretary of public security.

Beltrame is a principal author of the "pacification plan," meant to occupy the slums and push out the gangs with a force of some 12,500 pacification officers in 165 communities by 2014 for the soccer World Cup. Beltrame hopes to leave behind a functioning civilian state with a legal economy after the Olympics in 2016. Many citizens with high hopes believe Beltrame is the first security chief who is not corrupt. He's not from Rio either; his accent—and the gourd of maté tea tucked under his desk—is the mark

*Antonio Regalado writes about science, technology, and culture. David Alan Harvey's take on North Carolina's Outer Banks appeared in June 2012.*



A drug dealer holding bags of cocaine worth a few dollars apiece is one of a disappearing breed in Vidigal. Police officers who now occupy the favela are working to eradicate all such activity.

of a straight-talking gaucho from Brazil's southern plains. "I understood that we had to have a plan, not a bunch of opinions," says Beltrame. "The solution, without any doubt whatsoever, is what I am doing."

In other slums now occupied by police, life has improved. Children are playing again in the streets. Friends will come for a visit. Yet people are still suspicious. One of Fabio's fellow preachers, Sérgio Souza de Andrade, led me to the church basement to explain. "People don't want to say so, but our greatest fear is that tomorrow will be like yesterday," he says. "What will happen when the police leave?"

Consider Cantagalo, an amphitheater-shaped favela with sweeping views of Rio, where drug traffickers made the rules for roughly 35 years. Their spray-painted slogans, on building walls now covered with less violent graffiti by local artists, announced: "We are the crazies" or "Psychos are born here." Since police took over in December 2009, gang members have no longer been carrying unconcealed weapons. But they may not all have left either. "They're up there somewhere," says Luiz Bezerra do Nascimento, the community association president, waving a hand toward the top of the hill. Everyone is still sorting out the new roles. "We had to respect them before because they were the authority. Now I tell them, 'You don't rule here anymore. The police do.'"

The police are more welcome, if not beloved, in Cantagalo these days, partly because of a big publicity effort. It's a strategy as old as military

occupations, explained Capt. Leonardo Nogueira, who runs the local pacification unit. He was tossing candy out a window in police headquarters to a horde of children while a local TV crew filmed. "The children who live here without the influence of drug traffic will be different people. We want to come back here in 20 years and find that they're not like their parents," Nogueira says.

IN A WAY, with gangs gone, it's every man for his capitalistic self. Electricity in Santa Marta used to come free via a tangle of wires. Now everyone pays bills. But why does the amount go up and down so much every month? Real estate prices are soaring too. Nearby in more upscale Botafogo, once terrorized by stray bullets, apartment prices have more than doubled. Students and foreigners want a shack with a view in Santa Marta.

Despite the early success of the pacification plan, Rio's poor distrust many government efforts to reshape the city. Tempers rise periodically, as when workers began building a multimillion-dollar plastic and concrete wall along the Linha Vermelha highway a couple of years ago. Officials called it a sound barrier, but critics denounced it as a vanity screen to hide the squalid creeks of Complexo da Maré, an expanse of houses built on marshland, where residents used to clamber onto the highway leading from the airport to sell peanuts and cell phone chargers.

Similar doubts surround the coming Olympics spectacle. Half the new arenas and facilities will be in Barra da Tijuca, a Miami-like middle-class refuge full of cars and malls about 20 miles from the city center. Here the poor are less in evidence, and strangely, the charm of the *cidade maravilhosa,* the "marvelous city" that invented the world's great tropical brands—Carmen Miranda, "The Girl From Ipanema"—is also absent. The place is known as "the Rio that forgot it is Rio." A Spanish academic named Jordi Borja, who studies mega-events and has advised Rio's government, says, "You should use the games to improve the inner city, not the suburbs, to reduce inequalities, and to do urbanism in favor of the poor."

Certainly some real money is reaching impoverished areas, to good effect. In Cantagalo, two soaring elevators wrapped in colorful steel tubes now connect the upper reaches of the slum to the street. And the Complexo do Alemão, a confused agglomeration of several favelas that has been a main redoubt of the Red Command, Rio's largest gang, was recently abuzz with workers funded by a federal program. They erected a few thousand new apartments and a sports complex, and have completed work on an immense cable car system, based on the one in Medellín, Colombia, spanning the hills.

Some hope such structures will be like the London Tube or the Brooklyn Bridge: symbolizing civic values, the opening up of the slums, and the return of civil rights to all Cariocas, as Rio's residents call themselves. But others say it's asking too little of Rio—dominated as it is by natural wonders and human drama—to expect man-made structures to represent the city's aspirations, as the Bird's Nest declared Chinese power during the Beijing Olympics.

## Making History

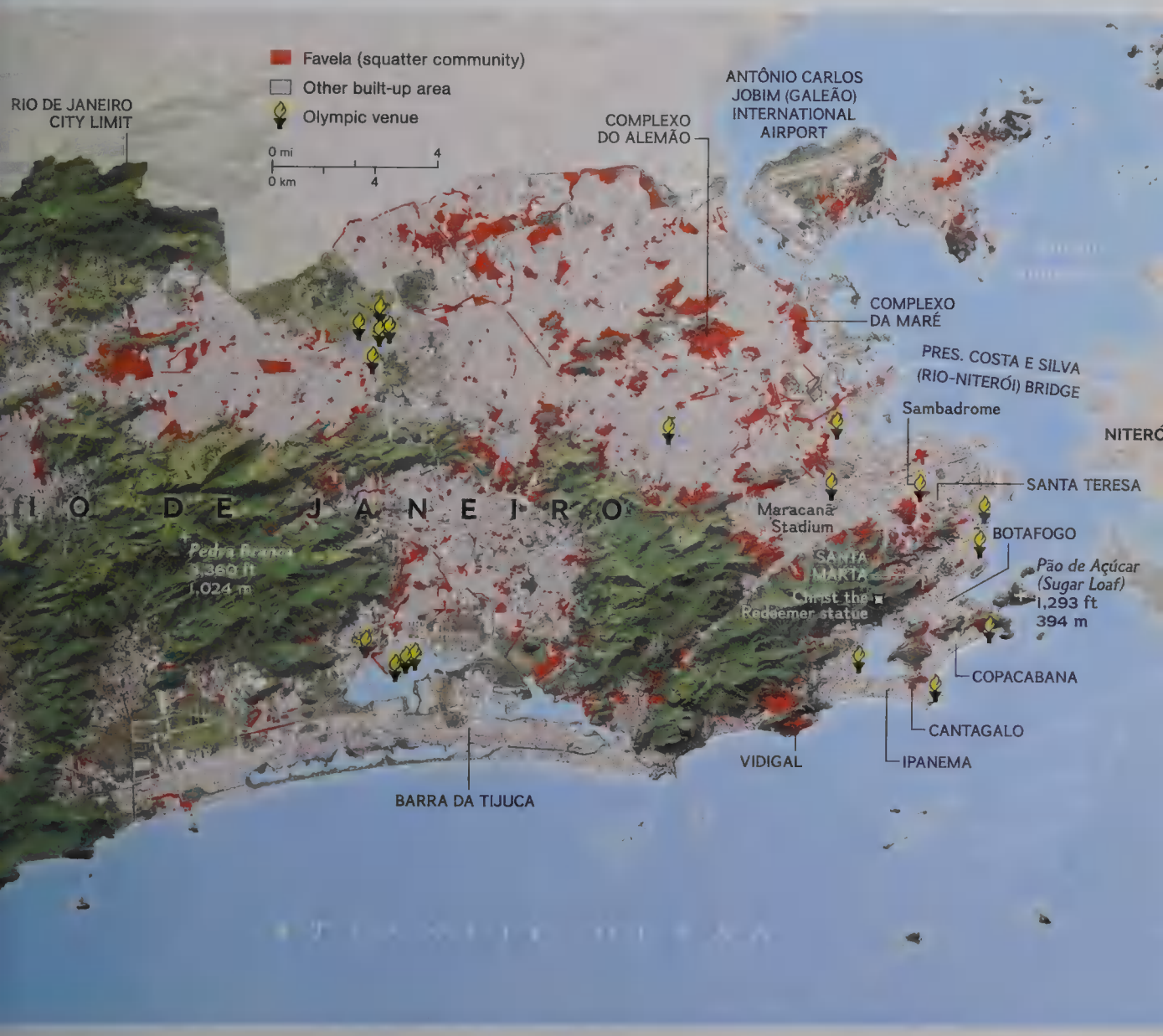
Portuguese explorers arrived at this harbor on the Atlantic in 1502. Having served as Brazil's capital until 1960, Rio is now a cultural center with a population of 6.3 million—almost a quarter in favelas. In 2016 it will bring the Olympics to South America for the first time.

Plus, people are sure the money will somehow be stolen, and they point to the City of Arts. The city that turned samba into a spectacle created a $250 million boondoggle: an immense, gloomy, concrete music hall in Barra da Tijuca that, ten years into construction, has yet to sound a note.

If you are looking for an Olympic legacy, how about a city where people live in peace? Since this is Rio, everyone says look to Carnival for answers. The festival is a time of inversion, a chance to stand the world on its head. "This is a city of celebration," says Mayor Eduardo Paes, "but we have to organize it. Carnival represents the kind of organized disorder we're trying to copy." During Carnival's big parades the poor dress as kings, beach-neighborhood socialites tear their clothes to parade as beggars, and 60,000 participants and close to a hundred floats—orchestrated and on time—samba like clockwork until dawn.

But Carnival is once a year. And even the big push to change Rio for the Olympics will eventually come to an end. Then the future of the favelas may rest in the hands of people like Brother Fabio, with his message of personal redemption.

His church stands next to a plaza with a statue of Michael Jackson; it's where the pop star recorded the music video "They Don't Care About Us." The church is full of poor children, and adults who can't escape from drugs. On a day when the building's metal shutters are closed against wet ocean wind, Fabio's voice booms over a tinny PA system. "The flesh is weak," he sings out, "and the spirit is strong." It is his fanfare for the common man, his dream for the favelas that shaped him. □




JEROME N. COOKSON, NGM STAFF; THEODORE A. SICKLEY. SOURCES: INSTITUTO PEREIRA PASSOS, RIO DE JANEIRO CITY HALL; RAPIDEYE; RIO 2016

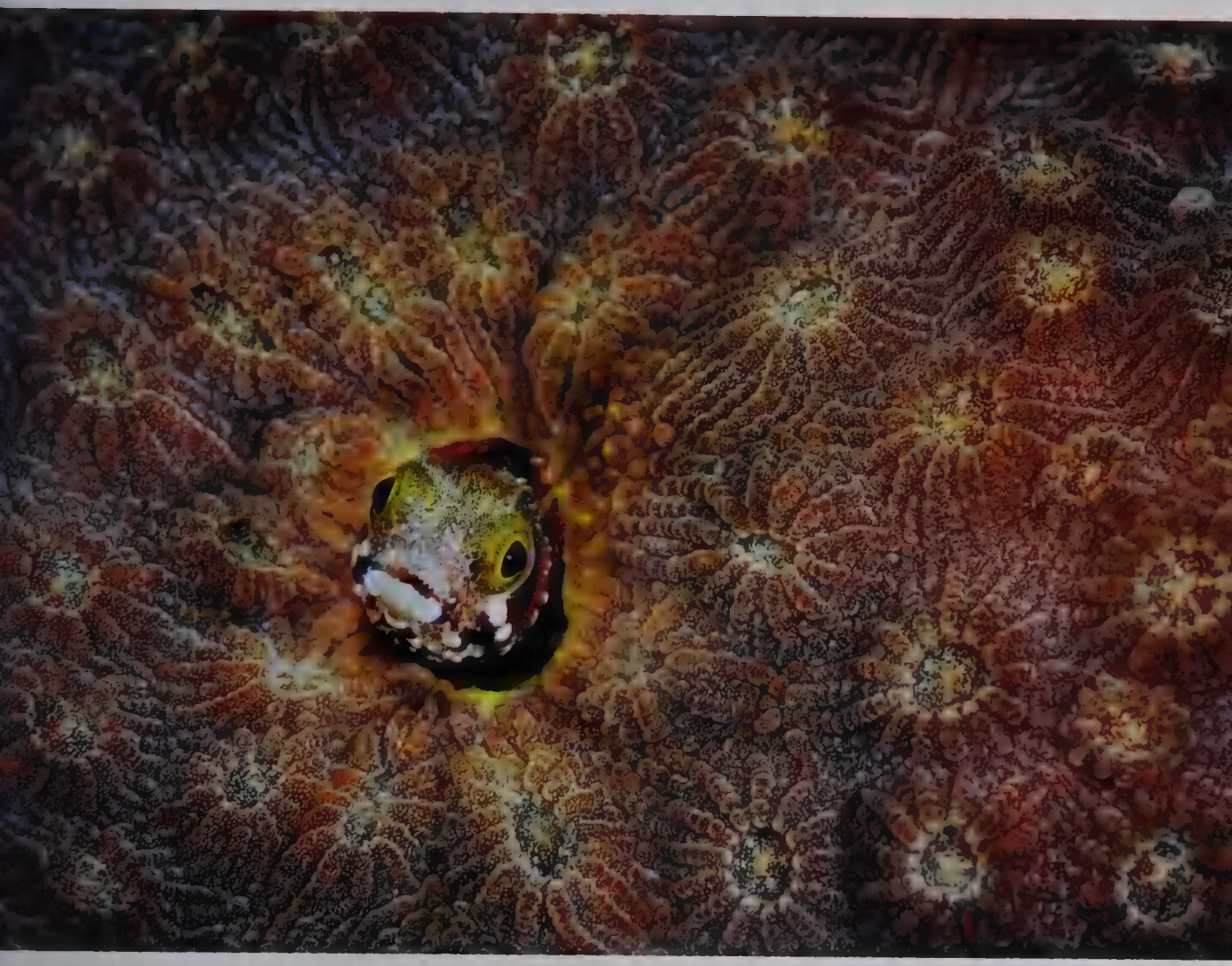
Despite Rio's deep social divisions, the beach is democratic. Rich and poor share the sand all day and into the evening.

Central America's **MESOAMERICAN REEF**
is half the length of its famous Australian counterpart
but in many ways more remarkable.

# MESO

AMAZING

A view from 12,000 feet off the coast of Belize, shows the parts of the system that make the whole. The outer reef breaks the force of the ocean swells. Next comes the white line of coral rubble along the reef crest, then the sandy back reef, and, finally, the lagoon, a maze of sand islets, mangrove cays, and sea grass beds.



**SEA GRASS**
*left*

A loggerhead turtle grazes. Sea grass is not the typical meal for the primarily carnivorous species, which feeds on jellyfish, crabs, and conchs.

**CORAL REEF**
*right*

Corals build the rampart that shelters the landward provinces of mangrove and sea grass. The reef's calcium carbonate city teems with species, among them this spiny-headed blenny.

**MANGROVE**
*following pages*

Mangroves contribute to the system by trapping reef-bound sediment, filtering out pollution, and serving as nursery for many reef fish and invertebrates. The arched roots of mangroves like these form gateways through which multitudes of juveniles swim toward adulthood on the reef.

By Kenneth Brower
Photographs by Brian Skerry

**IN THE MANGROVES OFF THE EAST COAST OF CENTRAL AMERICA, AT THE EDGE OF THE MESOAMERICAN REEF, THE WORLD IS DIVIDED IN TWO:**

the above and the below. As we killed the engines and poled the skiff from the hot April sun into the shade of the forest, Will Heyman, my marine biologist companion, and I gazed into the simplicity above. We saw the green crowns of one of the least diverse of all tropical forests, where there is often but a single species of tree, the red mangrove.

Salinity, storm waves, and oxygen-poor mud discourage understory growth in the mangroves, so there was little beneath the canopy for us to see. The occasional orchid. Rarely, a vine. A troop of fiddler crabs guarding holes in the mud. A big mangrove crab low on a trunk. Some insects. A tricolored heron perched on the stilt of a mangrove root.

I leaned over the gunwale to sample the mud around the roots, scooping up sherds of pottery. The mangroves of the Mesoamerican Reef were once at the fringe of the ancient Maya civilization. I contemplated slipping a souvenir into my pocket—with such a lode here, what possible harm? "Strictly catch-and-release," Heyman said. With a splashing of jettisoned sherds, we poled to another spot. There, in the still water, we witnessed the miracle of the below.

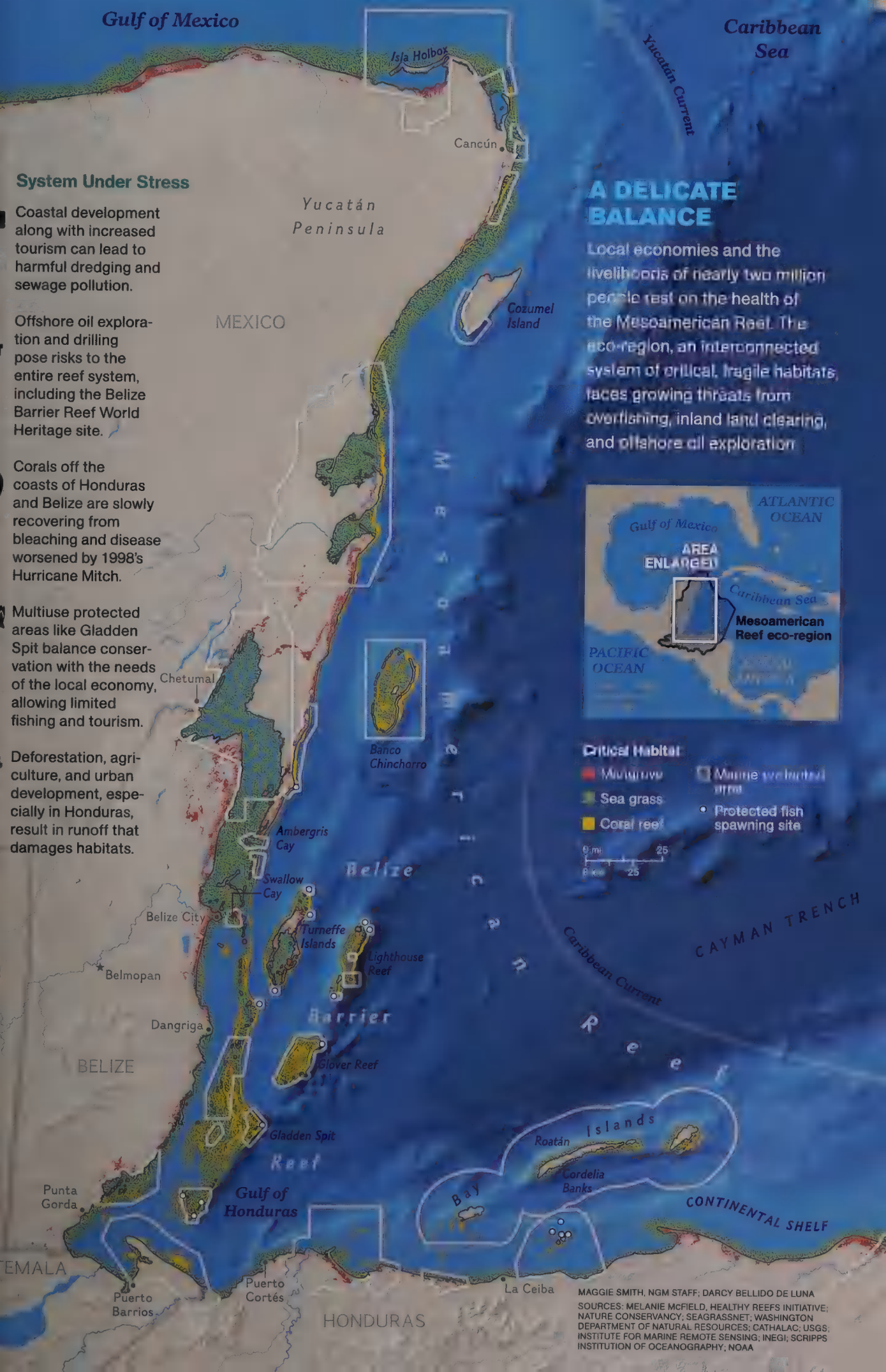
At the waterline the roots in this forest blossom downward, expanding all shaggy-bearded with mats of algae, and slender brittle stars, and boxy starfish, and the little translucent vases of the filter feeders called tunicates—their "tunics" orange or purple or white—and soft corals and oysters and sponges in still more hues. Nothing here goes unadorned.

Mangroves are crucial nurseries. Schools of small fry shift away through the Moorish architecture of arched roots, each school a pale cloud of translucent fish. The palest clouds are hardly there at all, composed of hatchlings no bigger than the smallest mosquito wigglers. These living motes are too small to name. Are they destined for adulthood in a sea grass bed, or coral reef, or open ocean, or right here in the mangroves? Too soon to tell.

And so it goes on Central America's reef system. Each component of this tripartite world of mangrove, sea grass, and coral reef is itself divided in two: the world above elementally simple, the one below bafflingly complex.

The Mesoamerican Reef system stretches more than 600 miles along the coasts of Mexico, Belize, Guatemala, and Honduras. Its Australian cousin, the Great Barrier Reef, is great indeed at 1,429 miles long—the biggest structure created by living things on this planet. Yet the Mesoamerican Reef, at less than half the length, is in its own way the more remarkable.

The contours of the continental shelf here encouraged the development of an underwater reef platform that begins within a few hundred yards of shore in some places and as much as 20 miles offshore in others. This platform supports a variety of reef types and a profusion of corals unique in the Western Hemisphere. If the




MAGGIE SMITH, NGM STAFF; DARCY BELLIDO DE LUNA

SOURCES: MELANIE McFIELD, HEALTHY REEFS INITIATIVE; NATURE CONSERVANCY; SEAGRASSNET; WASHINGTON DEPARTMENT OF NATURAL RESOURCES; CATHALAC; USGS; INSTITUTE FOR MARINE REMOTE SENSING; INEGI; SCRIPPS INSTITUTION OF OCEANOGRAPHY; NOAA

Mesoamerican Reef has any advantage over its massive Australian counterpart in the Pacific, it is in this proximity to land and the intimacy of its connection with inshore habitats. Here the provinces of mangrove, sea grass, and coral reef are bound so tightly together by currents, tides, and mutual need that it's really not possible to tease them apart.

## MANGROVES

Mesoamerican mangroves form multiple lines of defense for the reef system. The first line is the tall mangrove forest along the coast and up the mouths of tidal rivers. The second line, and sometimes a third and fourth, occur offshore, in places where pointy mangrove seedlings have taken root atop a series of shallow marine ridges. Each clump slowly gathers the makings of an islet under itself. These islets grow into islands—mangrove cays—arranged in linear archipelagoes. The clusters of cays work as screens, benefiting the sea grass by moderating wave action and the coral reef by intercepting silt, fertilizers, and toxins in runoff from land.

The mangroves, in addition to defense, provide mulch. They can shed tons of leaves per acre every year. Fungi and bacteria break down this leaf litter and consume it, then are consumed by tiny worms and crustaceans, which in turn feed small fish, which feed larger fish and birds and crocodiles.

Life wells outward from the mangroves into the sea. At the same time, a living countercurrent flows back in: the eggs, larvae, and sometimes the gravid females of reef creatures that use the mangroves as a nursery. If any fish is emblematic of this life cycle—kindergarten in the mangroves, graduate school on the reef—it is the rainbow parrotfish.

The scientific name for this species is perfect, *Scarus guacamaia,* from the native Taino *huacamayo,* "macaw." The resemblance is eerie: The fish has the parrot beak and the coloration of the blue-and-yellow macaw. The parrotfish starts small in the mangroves, as drab as a sparrow, and ends in full color on the reef, four feet long, the largest herbivorous fish in the Atlantic.

Mangroves are not just a convenience for *Scarus guacamaia.* They are a necessity. When mangroves are carved away, to make room for tourist venues, for example, the species tends to go locally extinct, with repercussions in all directions. Coevolution has brought the coral reef and its parrotfish into balance; when the horny-beaked herbivores are fished out or otherwise eliminated, the reef declines, its corals overgrown by carpets of the algae the parrotfish normally eat.

John Muir told us what we can expect when humans with their habits begin to unravel a sound ecosystem. "When we try to pick out anything by itself, we find it hitched to everything else in the universe," he wrote. The parrotfish are a case in point. The Mesoamerican Reef is one section of the universe where the hitches are particularly tight.

## SEA GRASS

A sea grass bed begins with the sprouting of a pioneer species like shoal grass, with flat, thin leaves; or long and threadlike manatee grass. The pioneer grasses eventually give way to turtle grass, the climax species, which has flat, straplike blades up to two feet long. Of the various species of sea grass identified off Central America, turtle grass is commonest. Like the others, it is an angiosperm, a flowering plant, having solved the problem of pollination underwater—no bees—and having mastered submarine dispersal of fruit, which simply detaches and tumbles away on the current. Sexual reproduction is not a big preoccupation of the species. Most of the time, turtle grass is chaste. Maintenance and expansion of the bed are largely by vegetative reproduction—asexual sprouting from buried stems.

The turtle-grass rhizomes, or underground stems, creep horizontally under the sand and are anchored by an extensive root system. Like the mangroves, they trap silt that might otherwise settle on corals.

This is a vital service. Reefbuilding corals

**HERE THE PROVINCES OF MANGROVE, SEA GRASS, AND CORAL REEF ARE BOUND SO TIGHTLY TOGETHER BY MUTUAL NEED THAT IT'S REALLY NOT POSSIBLE TO TEASE THEM APART.**

require clear water. The basic unit of a coral colony, the tiny coral animal—the polyp—produces most of its food through photosynthesis by algae resident in its tissues. Sedimentation, which screens out sunlight and kills polyps, is one of the principal causes of coral-reef decline worldwide. De-sedimentation by sea grass is a reciprocal service. Turtle grass thrives in calm waters protected from surf and wind-driven currents by the barrier reef; its sequestering of sediments is merely a return of the favor. Just as the coral polyp lives in internal symbiosis with its resident algae, so the coral reef lives in external symbiosis with sea grass.

All in these waters is quid pro quo. The Mesoamerican Reef is an edifice built of mutualisms.

From a boat adrift above it, the turtle grass looks as monotonous as a field of corn or alfalfa. But snorkel the prairie at the level of the grass, your face mask parting the blades, and the detail and diversity jump out. Older, darker blades are encrusted with epiphytes, undersea "mosses" in hundreds of species. Films of algae and bacteria on the blades are food for tiny organisms, which in turn feed shrimp and small fish. Sea grass is a way station, a middle school, for many species hatched in the protection of the mangroves and bound for adulthood on the reef.

Bright schools of small fish hang over the undersea prairie as the current stirs in the grass. Occasionally you flush adult parrotfish and surgeonfish, come in from the reef to feed on the grass itself. Sometimes in the turtle grass, you meet one of those: a foraging green turtle, hawksbill, or loggerhead. Here and there the sea grass prairie is crossed by what appears to be a game trail. The big game here is blimp shaped, weighs a thousand pounds or more, and is distantly related to the elephant: These are the feeding swaths of manatees.

When foraging in turtle grass, a manatee really digs in. Sometimes it starts with a salad of grass-blades, steering those toward its mouth with wafting, gathering motions of its foreflippers. But often it goes straight for the starch in the stems beneath. Rooting these out, it churns up clouds of sediment. The big myopic head lifts from the muck; the huge upper lip, muscular and prehensile, makes a variety of indescribable chewing motions, the broken ends of plants sticking out past the whiskers; and then the manatee is obscured by the mud cloud it has made. A blizzard of detached turtle-grass leaves swirls above the cloud, like confetti on Armistice Day. Burying its face in the mud again, the manatee rejoins its own parade, plowing onward across the prairie.

### CORAL REEF

From the deck of a skiff on the surface, the reef makes a lovely but minimalist seascape: the white line of surf breaking along the reef front, the turquoise of the reef flat, the royal blue of the open ocean beyond. But like the inshore habitats that it shelters, the rampart of the barrier reef is a world divided.

Adjust your mask, take a breath, and roll overboard. Now the real reef reveals itself: a concentration of life and a spectrum of colors unlike anything up in the world of air. The reef is a teeming city of hard corals, soft corals, fire corals, lace corals, brain corals, staghorn corals, sea whips, sea fans, sea grapes, coralline algae, sponges. Taking refuge everywhere in the alleys of the coral city, or countersunk in holes drilled in the corals themselves, or perched atop the coral heads, are hosts of invertebrates—clams, crabs, shrimps, worms, sea cucumbers—of stunning diversity. Add to these the hundreds of new species scientists identify worldwide each year.

Schooling above the reef are fish painted extravagantly in an array of electric colors we are missing in the upper world. There is an autoluminescence to the palette here, as if each fish and feather worm came equipped with its own battery to power its stripes, bars, blazes, and dots.

The coral reef, like all reefs across the tropics, is threatened by ocean acidification and warming episodes caused by climate change. Overfishing,

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*Ken Brower contributed to* Ocean, *a 2010* National Geographic *special edition. For another of Brian Skerry's photos, see The Moment, page 145. This article was funded in part by the Oak Foundation.*

A manatee mother with her calf in tow grazes on turtle grass at Swallow Cay in Belize. The West Indian manatee divides its time between sea grass pastures and the waterways of the mangrove forest.

coastal development, and the accelerating pace of oil exploration are worrisome too.

But at dusk in springtime, when the moon is full, age-old magic still happens. Near the Silk Cays off southern Belize, thousands of cubera snappers, dog snappers, and mutton snappers come to spawn at a reef called Gladden Spit. They draw platoons of whale sharks, which feast on the eggs, and sometimes marine scientists as well. These sharks, the biggest fish in the sea, are plankton-eaters; Gladden Spit is the first place they have ever been observed eating spawn. The assembly here of snappers, the predators that eat them, and the colossal sharks that feed on the spawn is the most spectacular convocation I have ever witnessed in the ocean.

In scuba gear, 50 feet deep, Heyman and I swam toward a huge ball of spawning cubera snappers, a dark, slow-rotating, cyclonic tower that resolved itself, as we swam close, into thousands of particular fish. From the smooth rotation, tight groups flurried upward to spawn, releasing white clouds of eggs and milt. These coalesced into a great thunderhead, which billowed up to envelop us. For a time we were lost in a sperm-and-egg whiteout. Then a dim gray shape materialized, like *Titanic* in the fog, and out of the whiteness came the gigantic gape and spread pectoral fins of a feeding whale shark. Then more whale sharks arrived, and finally bottlenose dolphins and bull sharks.

We chased the party until we ran out of air. Surfacing, we inflated our vests and swam backward toward the skiff anchored under the newly risen moon. The full April moon had called snappers here, their spawning timed to catch the high spring tide that would carry their fertilized eggs into the mangroves. The whale sharks were guided in from afar by whatever mysterious cues they use in navigation. Tonight the shallow, tight-knit ecosystems of the Mesoamerican Reef had opened up. When you try to pick out anything by itself, you find it hitched to everything else in the solar system.

We paced ourselves, finning backward toward the bobbing skiff, under the moon that had brought us. □

A Caribbean reef shark samples a Pacific lionfish at Cordelia Banks in Honduras. A few spiny lionfish escaped from an aquarium 20 years ago, and today they're a plague, preying on the reef's fish population. Scientists are helping sharks acquire a taste for the invaders by feeding them speared lionfish.

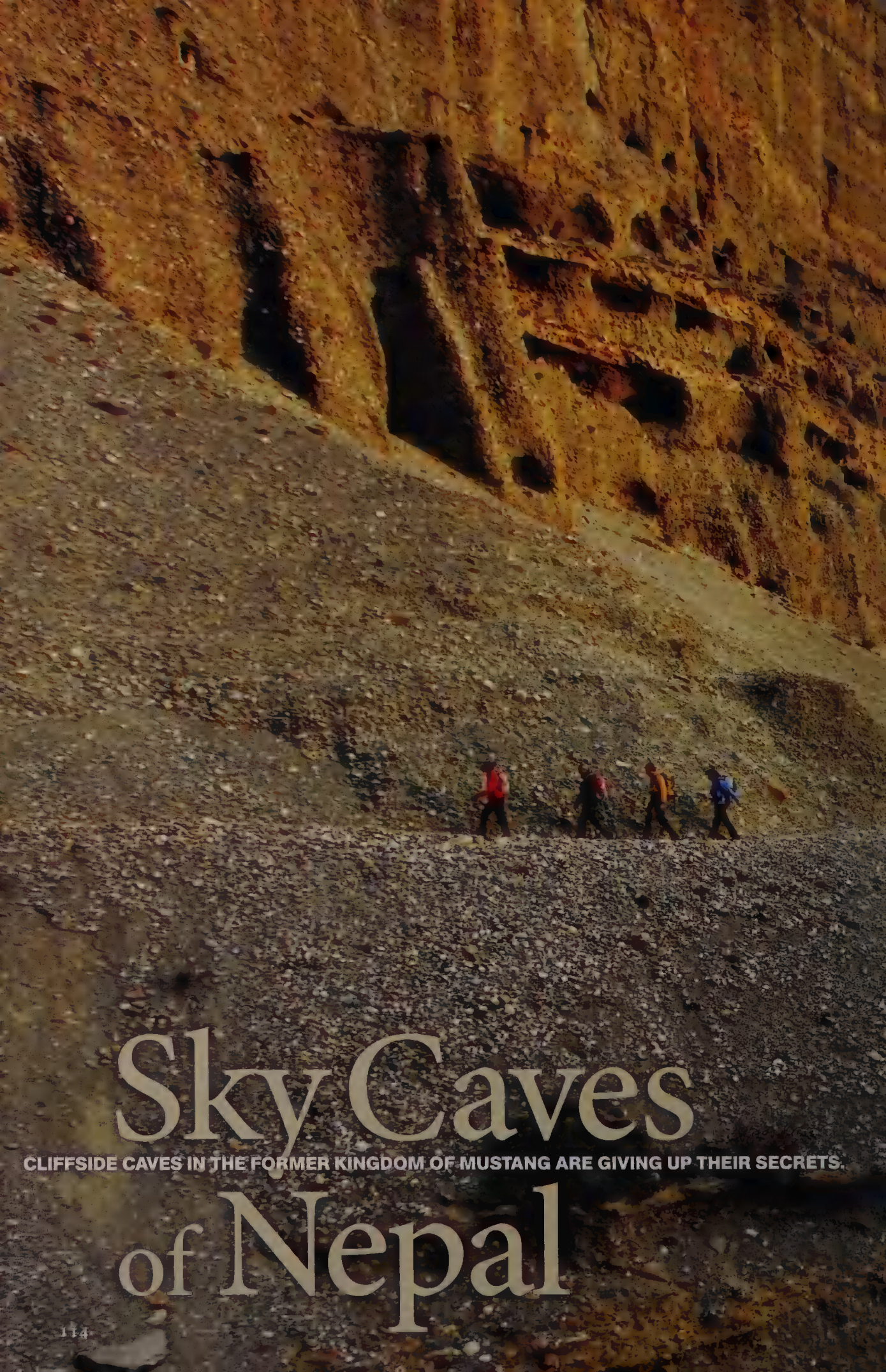
Three-foot-long cubera snappers drawn to Glandan Reef in Belize by a full moon in spring, produce clouds of eggs and sperm in a thunderhead of fertility that rises to envelop divers. Snappers of several species gather here by the thousands, releasing hundreds of billions of eggs.

**CORAL REEF**
*left and right*

A trumpetfish (left) hangs in the coral gardens of Lighthouse Reef atoll off Belize (right), one of the most seaward outliers of the Mesoamerican Reef.

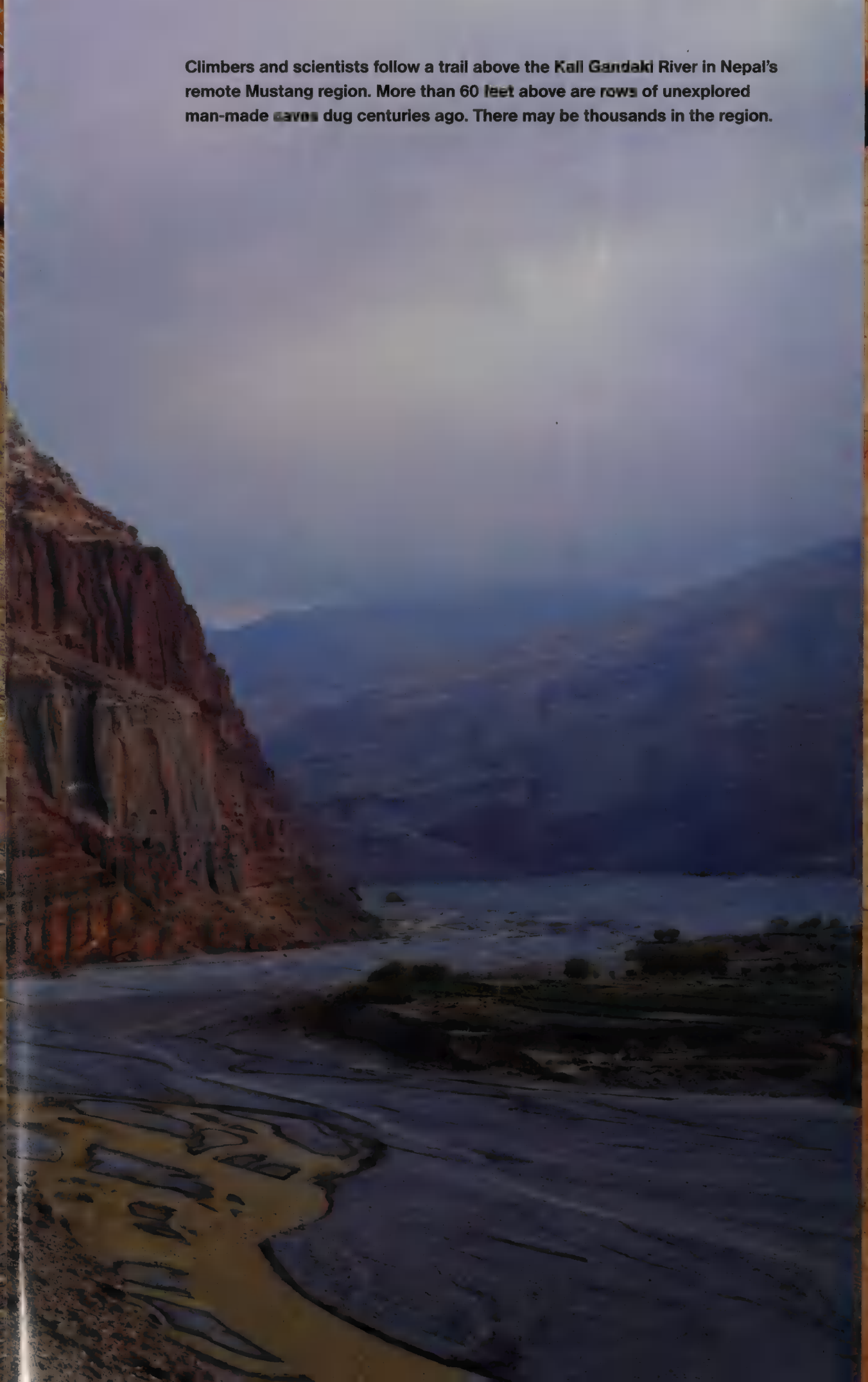
**SEA GRASS**
*following pages*

A nine-foot American crocodile, an endangered species, hunts in turtle grass at the edge of a bed of mangroves on Banco Chinchorro, off the Yucatán Peninsula. "Just make sure, whatever happens, that my body comes back home," muttered Jeff Wildermuth, photographer Brian Skerry's assistant, as he and Skerry entered the water. "I don't want to be stuffed under a mangrove log somewhere." When Wildermuth poked at the advancing croc with a length of plastic pipe, it did not veer off, as a shark would have. It opened its jaws and kept coming. "There's nothing quite like the feeling of being hunted," said Skerry after he and Wildermuth escaped.

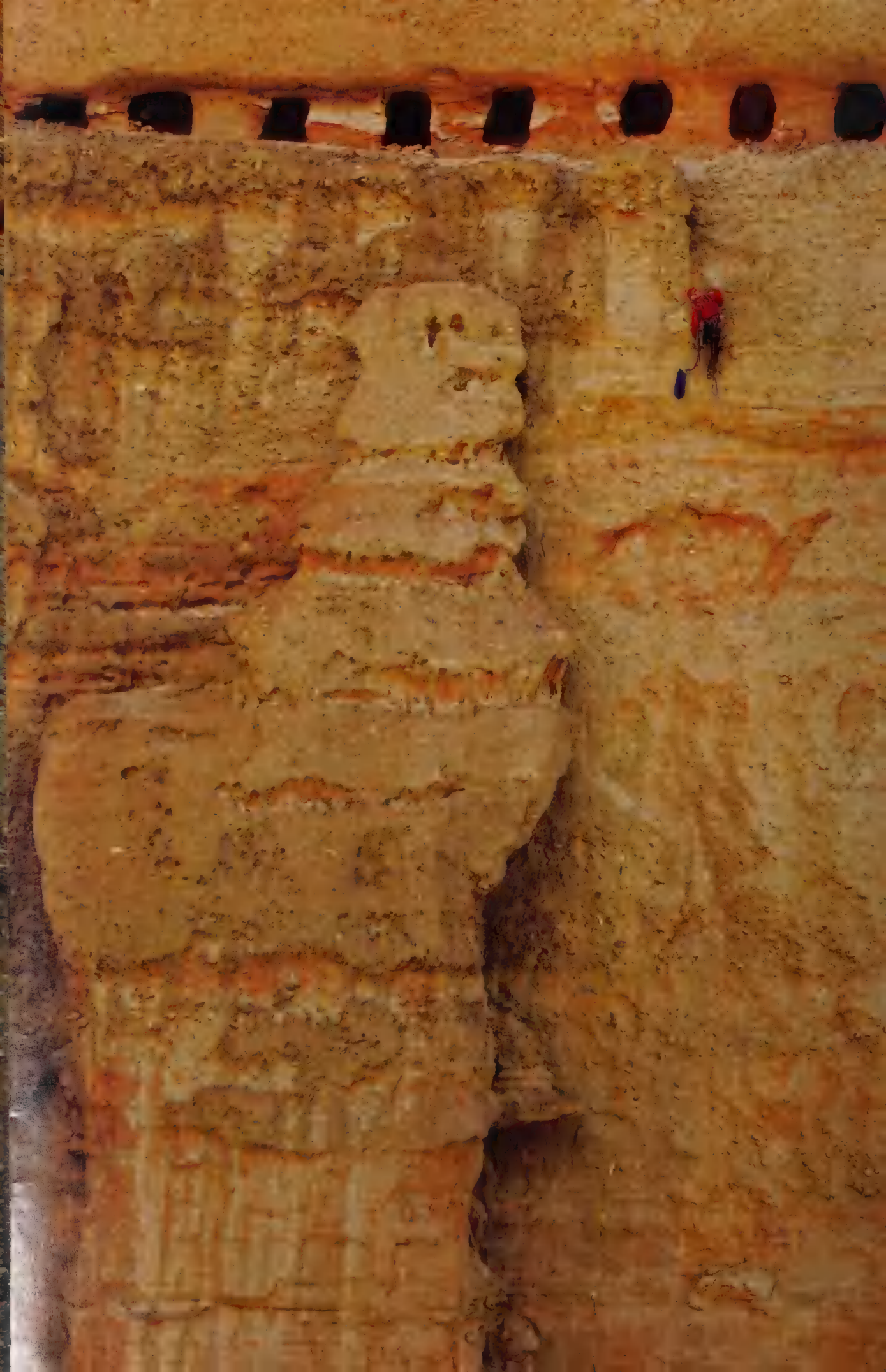


# Sky Caves of Nepal

CLIFFSIDE CAVES IN THE FORMER KINGDOM OF MUSTANG ARE GIVING UP THEIR SECRETS.



Climbers and scientists follow a trail above the Kali Gandaki River in Nepal's remote Mustang region. More than 60 feet above are rows of unexplored man-made caves dug centuries ago. There may be thousands in the region.



To reach a series of caves dug into a cliff 155 feet above the valley floor, Matt Segal (above) scales a rock face so fragile it breaks off to the touch. Linked by a ledge, the 800-year-old caves, [illegible] once have stored manuscripts. Ted Hesser (left) hoists himself up at [illegible] entrance.

BY MICHAEL FINKEL
PHOTOGRAPHS BY CORY RICHARDS

# The skull, a human skull, was perched atop a crumbly boulder in the remote northern reaches of the Nepalese district of Mustang. Pete Athans, the leader of an interdisciplinary team of mountaineers and archaeologists, stepped into his harness and tied himself to a rope. He scrambled up the 20-foot boulder, belayed by another climber, Ted Hesser.

When he reached the skull, he pulled on blue latex gloves to prevent his DNA from contaminating the find, and gradually removed it from the rubble. Athans was almost certainly the first person to hold this skull in 1,500 years. Dirt spilled from the eye cavities. He placed it in a padded red bag and lowered it to three scientists waiting below: Mark Aldenderfer of the University of California, Merced; Jacqueline Eng of Western Michigan University; and Mohan Singh Lama of Nepal's Department of Archaeology.

Aldenderfer was especially excited by the presence of two molars. Teeth can provide insights into a person's diet and health and general place of birth. Eng, a bio-archaeologist, swiftly determined that the skull likely belonged to a young adult male. She noted three healed fractures on the cranium and one on the right jaw. "Signs of violence," she mused. "Or maybe he was kicked by a horse?"

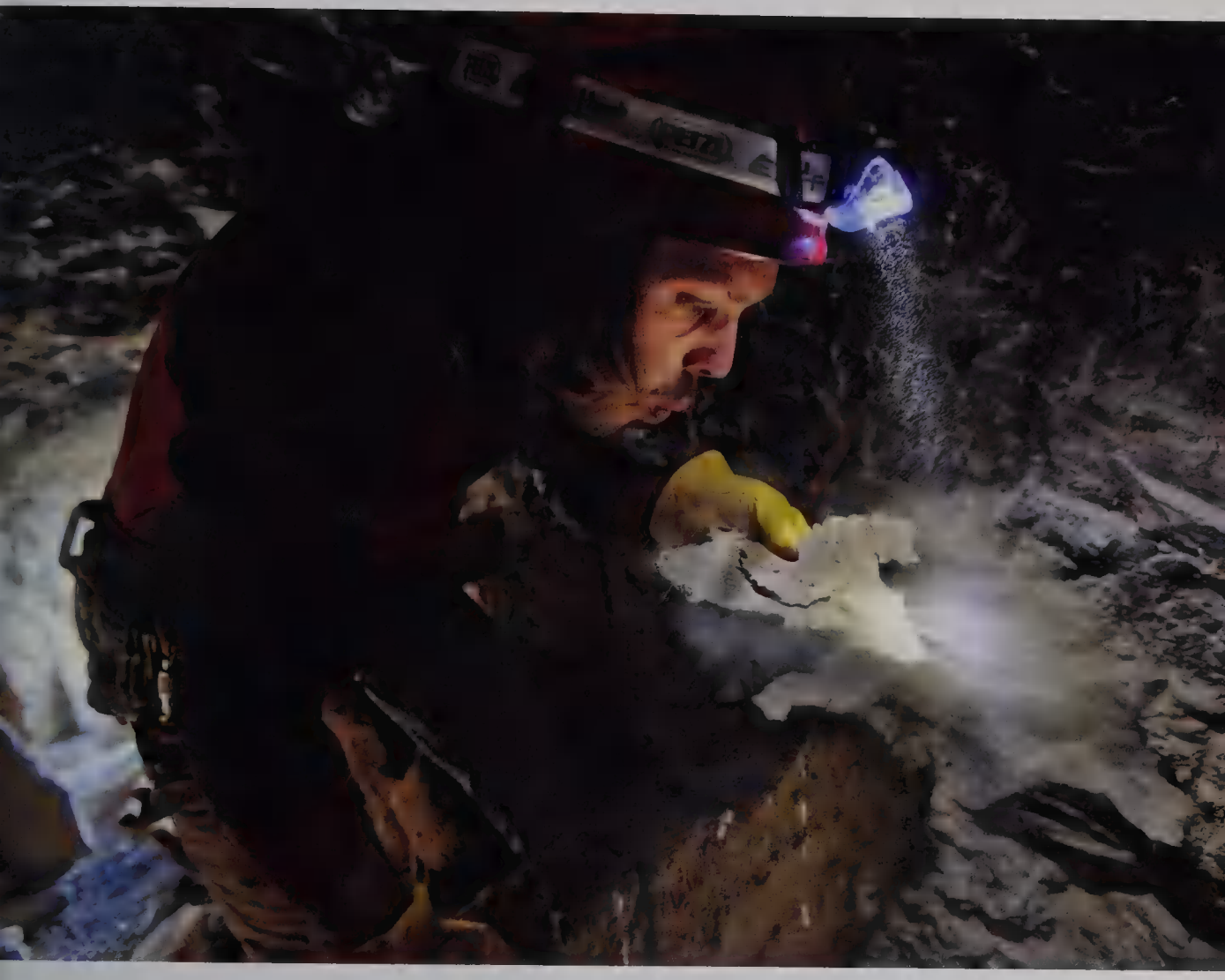
But more intriguing than the skull itself was where it fell from. The boulder Athans scaled sat directly below a soaring cliff, tan rock streaked with bands of pink and white. Toward the top of the cliff were several small caves, painstakingly hand-dug from the brittle stone. Erosion had triggered the partial collapse of the cliff face, dislodging the skull. Now the same tantalizing question was on everyone's mind: If a skull tumbled out, what remained up there?

MUSTANG, A FORMER KINGDOM in north-central Nepal, is home to one of the world's great archaeological mysteries. In this dusty, wind-savaged place, hidden within the Himalaya and deeply cleaved by the Kali Gandaki River—in spots, the gorge dwarfs Arizona's Grand Canyon—there are an extraordinary number of human-built caves.

Some sit by themselves, a single open mouth on a vast corrugated face of weathered rock. Others are in groups, a grand chorus of holes, occasionally stacked eight or nine stories high, an entire vertical neighborhood. Some were dug into cliffsides, others tunneled from above. Many are thousands of years old. The total number of caves in Mustang, conservatively estimated, is 10,000.

No one knows who dug them. Or why. Or even how people climbed into them. (Ropes? Scaffolding? Carved steps? Nearly all evidence has been erased.) Seven hundred years ago, Mustang was a bustling place: a center of Buddhist scholarship and art, and possibly the easiest

*In the August issue, Michael Finkel wrote about a medicinal Tibetan fungus. This is photographer Cory Richards's first story for the magazine.*



**Matt Segal blows dust off a manuscript fragment found in a cache of documents. Most pages date to the 15th century and cover topics both sacred and mundane, from Tibetan Buddhist doctrine to legal matters.**

connection between the salt deposits of Tibet and the cities of the Indian subcontinent. Salt was then one of the world's most valuable commodities. In Mustang's heyday, says Charles Ramble, an anthropologist at the Sorbonne in Paris, caravans would move across the region's rugged trails, carting loads of salt.

Later, in the 17th century, nearby kingdoms began dominating Mustang, says Ramble. An economic decline set in. Cheaper salt became available from India. The great statues and brilliantly painted mandalas in Mustang's temples started crumbling. And soon the region was all but forgotten, lost beyond the great mountains.

Then, in the mid-1990s, archaeologists from the University of Cologne and Nepal began peeking into some of the more accessible caves. They found several dozen bodies, all at least 2,000 years old, aligned on wooden beds and decorated with copper jewelry and glass beads, products not locally manufactured, reflecting Mustang's status as a trade thoroughfare.

Pete Athans first glimpsed the caves of Mustang while trekking in 1981. Many of the caves appear impossible to reach—you'd have to be a bird, it seems, to gain entry—and Athans, an exceptionally accomplished alpinist who has stood atop Everest seven times, was stirred by the challenge they presented. It wasn't until 2007, however, that he secured the necessary permits. Mustang immediately became, he says, "the greatest expedition of my life." This trip in the spring of 2011 was his eighth to the area.

During previous visits Athans and his team

**In the private chapel of a home in the city of Lo Manthang, a Tibetan Buddhist lama performs a rite with cymbals, drum, and incense. Once part of greater Tibet, Mustang remains suffused with Tibetan culture.**

had made some sensational finds. In one cave they discovered a 26-foot-long mural with 42 exquisitely rendered portraits of great yogis in Buddhist history. In another was a trove of 8,000 calligraphed manuscripts—a collection, most of it 600 years old, that included everything from philosophical musings to a treatise on mediating disputes.

What Athans and the scientists wanted most was a cave with items from before the era of written records to shed light on the deepest mysteries: Who first lived in the caves? Where did these people come from? What did they believe?

Most of the caves Athans had peeked into were empty, though they showed signs of domestic habitation: hearths, grain-storage bins, sleeping spaces. "You can spend your life looking in all the wrong caves," says Aldenderfer, whose long career as an archaeologist has included no shortage of frustrating quests.

The ideal cave, he felt, would be one used as a cemetery rather than a home, with pre-Buddhist-era ceramic remains scattered below, on a cliff too high for looters to reach, in a part of Mustang where locals are comfortable with foreigners disturbing their ancestors' bones. All this, and one additional factor. "Sometimes," Aldenderfer admits, "you just need to get lucky."

THE MOST PROMISING SITE was a cave complex near a tiny village called Samdzong, just south of the Chinese border. Athans and Aldenderfer had

visited Samdzong in 2010 and found a system of funerary caves. On the first workday at the site in the spring of 2011, during a scouting hike at the base of the caves, the team's photographer, Cory Richards, noticed the skull.

The next morning, the climbers prepared to investigate the caves above the skull find. Mustang's cliffs are gorgeous beyond measure—the immense walls appear to be melting like so much candle wax under the intense high-elevation sun. The ridgelines have eroded into wild shapes: bony fingers supporting colossal rocky basketballs, towering tubes arrayed like an endless pipe organ. The color of the rock, shifting as the day passes, seems to encompass every shade of red and ocher and brown and gray.

But the climbing is horrible. "Pure thuggery," says Athans. "Industrial, inelegant—the Dumpster diving of climbing." The rock, fragile as peanut brittle, breaks off with every touch. It's extraordinarily dangerous. A few months earlier, Lincoln Else, a videographer, was struck in the head with a rock shortly after he'd removed his helmet. His skull was fractured. He underwent emergency brain surgery in Kathmandu and survived. In 2010, Richards, a climber as well as a photographer, tumbled and broke a bone in his lower back. Like Else, he had to be evacuated from Mustang by helicopter.

To access Samdzong's caves, Athans and Hesser, the team's chief climbers, hiked around the back side of the cliff and reached a flat area above the caves. Here, with special permission from authorities, they hammered several long pieces of rebar into the rock and tied on a rope. Athans was going to entrust his life to this anchor. There was a discussion of what to do if the rebar started to loosen. Hesser suggested that he shout an expletive at the top of his lungs.

"That will work," said Athans. He then calmly rappelled off the edge. A rain of dirt and rocks clattered off the dome of his helmet.

Below, on flat ground, sat Aldenderfer, his prodigious mane of silver hair corralled by a red bandanna—he hasn't had a legitimate haircut, he says, in 20 years. Aldenderfer held a small monitor that received a wireless feed from Athans's video camera, allowing the anthropologist to direct the search from a safe position.

Nearby, sitting cross-legged in his maroon robe, was the local lama, 72-year-old Tsewang Tashi. He lit a small juniper twig fire and filled a chalice with holy water from an old plastic Pepsi bottle. Then he chanted softly while ringing a brass bell and dipping his fingers in the water—a Buddhist protection ceremony to remove troublesome spirits that could endanger the team's work.

Athans, dangling on the green rope, maneuvered nimbly into the smallest cave. He had to crouch to get in—it was only five feet high and roughly six feet wide and six feet deep. This cave, it was clear, was once a hidden shaft tomb, or mortuary cave, dug in the shape of a wine decanter. When it was excavated, only the very top of the shaft was visible. Bodies were lowered down the sewer-pipe-size shaft, and the hole was backfilled with rock. When the cliff face collapsed, the entire cave was exposed, creating a cross-sectional view.

A large boulder, once part of the ceiling, had landed on the cave's floor. If there was anything in the cave, it was beneath that rock. Athans tugged at it, levering it gradually toward the cave's mouth. Then he shouted, "Rock!" and the boulder thundered down the wall, kicking up a cloud of amber dust. Fifteen centuries or so after it was sealed, as carbon dating later proved, the cave was once again clear of debris.

ALDENDERFER DIVIDES CAVE USE in Mustang into three general periods. First, as long as 3,000 years ago, the caves were burial chambers. Then, around 1,000 years ago, they became primarily living quarters. Within a few centuries, the Kali Gandaki Valley—the neck in the hourglass connecting Asia's highlands and lowlands—may have been frequently battled over. "People were scared," Aldenderfer says. Families, placing safety over convenience, moved into the caves.

Finally, by the 1400s, most people had moved into traditional villages. The caves were still used—as meditation chambers, military lookouts, or storage units. *(Continued on page 130)*

Tsewang Tashi, a Tibetan Buddhist lama, leads his horse through the village of Samdzong, near the Chinese border. During a turbulent era two years ago, residents likely took refuge in caves, returning to the village generations later, after the region stabilized. "One good place to live, if you're worried about your neighbors, is in caves," says archaeologist Mark Aldenderfer.

# Cliff Caves of the Dead

The adult in Tomb 5 in Samdzong, wearing a gold-and-silver funerary mask, was probably a local leader 1,300 to 1,800 years ago. Iron daggers, a copper pot, and sacrificed animals reflect his status, as does a painting depicting a man, horses, and trees on his well-preserved wooden coffin.

Yak horns
in the
criffins
The mystery of defleshing
on the iPad
CHINA (TIBET)
Plateau of Tibet
Samdzong
Lo Manthang
12,497 ft
3,809 m
Tsarang
MUSTANG
NEPAL
Kali Gandaki
Mebrak
Jomsom
Dhaulagiri
26,795 ft
8,167 m
HIMALAYA
0 mi 10
0 km 10
The Samdzong tombs
Tomb 5
area
15 ft

## Mummies of Mustang

An infant and an adult female's foot were among the naturally mummified remains of 30 people discovered in a mortuary cliff cave at Mustang's Mebrak site in 1995 by German and Nepalese archaeologists. Dating back some 2,000 years, the bodies were bound with cloth strips and placed in wooden coffins with copper bangles, glass beads, and shell necklaces.

Some caves remained homes, and even today a few families live in them. "It's warmer in winter," says Yandu Bista, who was born in 1959 in a Mustang cave and resided in one until 2011. "But water is difficult to haul up."

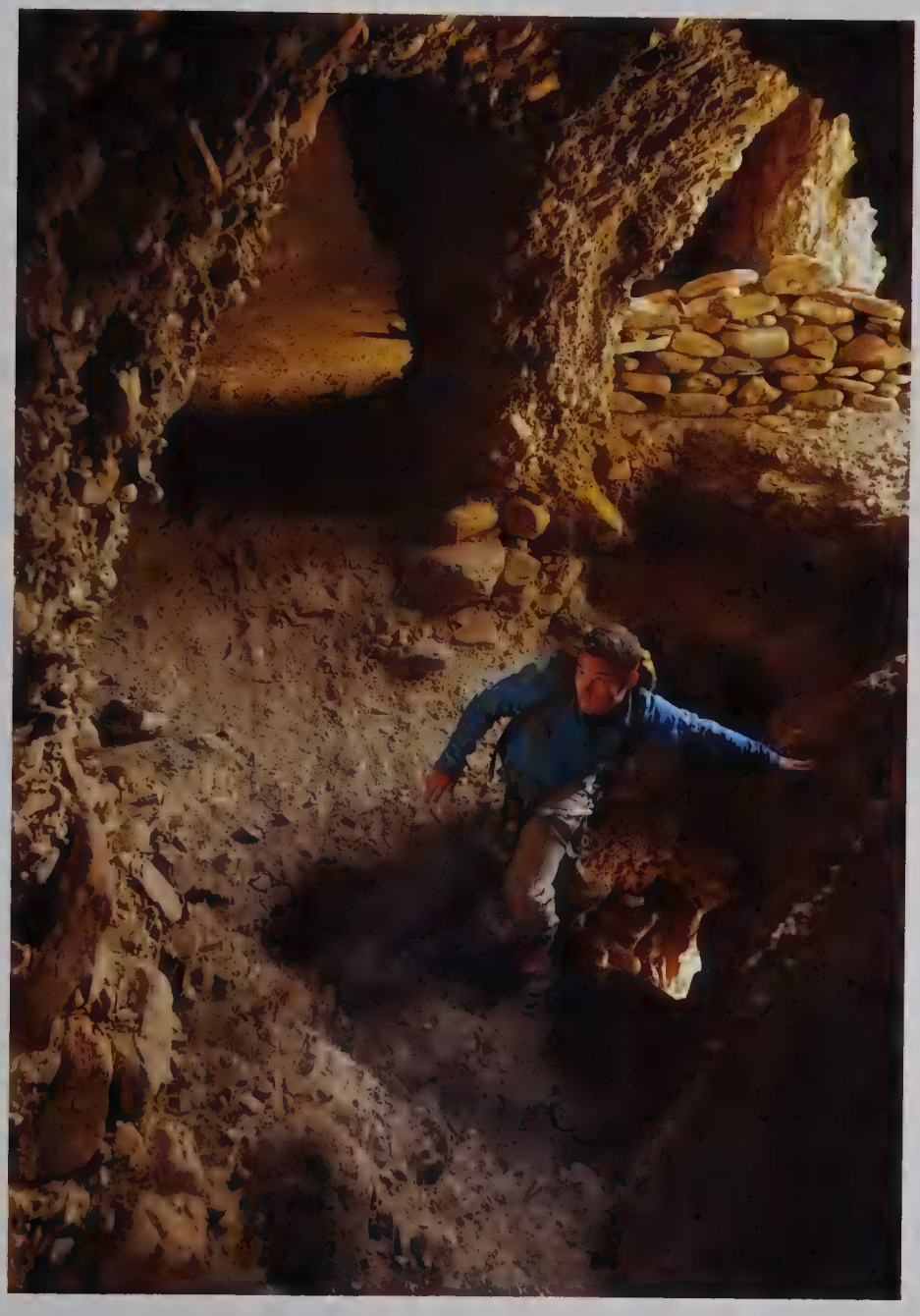
The first thing Athans found in the closet-size chamber—later designated Tomb 5—was wood, superb dark hardwood, cut into various planks and slats and pegs. Aldenderfer and Singh Lama eventually fitted the pieces together, creating a box about three feet tall: a coffin. It was ingeniously constructed so that the sections fit through the tomb's narrow entrance and then could easily be assembled in the main chamber. "Like Ikea before Ikea," says Eng.

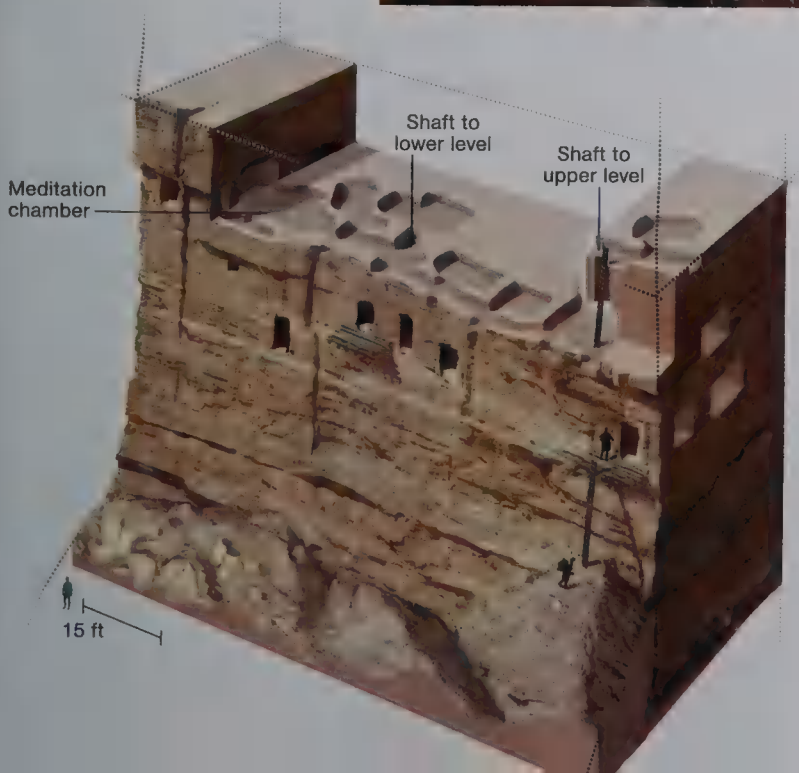
Painted on the box, in orange and white pigments, was a rudimentary but unmistakable image: a person riding a horse. "Probably his favorite horse," Aldenderfer guessed. Later, as if to confirm the man's status as an equine aficionado, a horse skull was found in the cave.

On the 2010 trip to Samdzong, in the two biggest caves on the cliff wall, the team had located human remains from 27 individuals, including men, women, and one child. There were bedlike or rudimentary coffins in those caves as well, but they were made of much inferior wood and far

**Society Grants** Aldenderfer's and Athans's research was funded in part by your membership.

Walkie-talkie in one hand and human jawbone in the other, expedition leader Pete Athans picks his way through a looted mortuary cave while Matt Segal surveys a pit from which robbers tossed bones. Scientists hope that DNA from teeth will help pinpoint the origins of the bodies. At right, Ted Hesser enters a maze of rooms in a looted cave where people once lived.






## Cities in Stone

With its storage rooms, meditation chambers, and ledges, the cave complex near the town of Tsarang served as a cliffside annex for the community. The many functions are typical of the apartment-style caves of Mustang. Shielded by a rocky facade, a series of chambers were intricately linked. Narrow shafts, up to 15 feet long, provided access between different levels.

FERNANDO G. BAPTISTA AND MATTHEW TWOMBLY, NGM STAFF
SOURCE: MARK ALDENDERFER, UNIVERSITY OF CALIFORNIA, MERCED

Dusk falls over the temples and homes of Tsarang, once the region's most important town. In Mustang, where the centuries have not disrupted the traditional rhythm of life, the ruins offer clues to a time when the remote Himalayan kingdom was a hub linking Tibet to the rest of the world.

simpler construction, with no paintings.

Tomb 5, Aldenderfer theorized, was the burial plot of a high-ranking person, perhaps a local leader. The tomb, it turned out, held two bodies—an adult male and a child, maybe ten years old. The youth was a source of much speculation. "I don't want to characterize the child as any kind of sacrifice or slave because I really don't have a clue," says Aldenderfer. "But a child in there does suggest a complex ritual."

When Eng, the team's bone sleuth, took a close look at the remains, she made a startling discovery: The bones of 76 percent of all the individuals she examined bore the unmistakable scars of knife slices. These marks, says Eng, were clearly made after death. "This wasn't hacking and whacking," she says. The bones were relatively whole and lacked signs of deliberate breakage and burning. "All the evidence," Eng notes, "indicates there was no cannibalism here."

The bones date from the third to the eighth centuries—before Buddhism came to Mustang—but the defleshing may be related to the Buddhist practice of sky burial. To this day, when a citizen of Mustang dies, the body may be sliced into small pieces, bones included. These are all swiftly snatched up by vultures.

In the age of the Samdzong cave burials, Aldenderfer posits, the body was stripped of flesh but the bones were still articulated—"like a Halloween skeleton," he says. The skeleton was lowered into the tomb and folded to fit in the wooden box. "Then whoever was down there with him," says Aldenderfer, "climbed back out."

BEFORE DOING SO, the ancient burial crew had made sure the corpse was regally adorned for the great beyond. As Athans hunched inside Tomb 5, sifting through dust for hour upon hour, he discovered these adornments. "It was so mesmerizing," he says, "that I forgot to eat or drink."

A trove of beads, the garment they'd been sewn on long disintegrated, was scooped up by Athans and placed in plastic sample bags. Singh Lama painstakingly sorted them. There were more than a thousand beads, made of glass, some as minuscule as poppy seeds, in a half dozen hues. As lab studies later showed, the beads were of various origins: some from what is now Pakistan, some from India, some from Iran.

Three iron daggers, with gracefully curved hilts and heavy blades, also emerged. Then a bamboo teacup with delicate circular handle. A copper bangle. A small bronze mirror. A copper cooking pot and a ladle and a three-legged iron pot stand. Bits of fabric. A pair of yak or cow horns. An enormous copper cauldron, roomy enough to boil a beach ball. "I'm betting that's a chang pot," said Aldenderfer, referring to the regional beer made of fermented barley.

Finally Athans sent down a funerary mask. It was made of gold and silver pounded together, with high relief facial features. The eyes were rimmed in red, the mouth was slightly turned down, the nose was linear; there was a hint of a beard. Pinholes outlined the edge. Likely the mask was sewn to fabric and draped over the face. The beads had been part of the mask.

Aldenderfer, normally restrained and scholarly, could not contain himself as he cradled the mask in his palms. "It's stunning," he marveled. "The workmanship that's involved, the obvious wealth it represents, the colors, the delicateness—it's the best thing ever found in Mustang. Period."

Nearly all the items in the cave had been imported from elsewhere. Even the coffin's wood had come from a tropical environment. How could a person from this place—today so bereft of resources that merely accumulating firewood requires hours of effort—gather such riches? Salt, most likely. Controlling a piece of the salt trade may have been the current equivalent of owning an oil pipeline.

The entire haul, from what seemed a nondescript cave, left Aldenderfer giddily struggling to place the find in historical context. "This is unique," he said. "Spectacular. This is rewriting the region's prehistory in a serious way."

EVERYTHING THE TEAM FOUND was left behind, in the care of Samdzong's village leaders. Athans, as he's done elsewhere in Mustang, also donated personal funds to endow a modest museum. "The people of Mustang should have pride in

**Jacqueline Eng, a bio-archaeologist, examines 1,500-year-old human and animal bones from mortuary caves as ■ Samdzong villager looks on. Shallow cuts on many human bones suggest ritual removal of flesh.**

their own rich history," he says. Only tiny sample chips and bits of bone were removed by the scientists. These will be studied in various labs—teeth go to the University of Oklahoma; metals to University College London. Paints will be separated into chemical constituents, to see which plants were used to make them. A splinter of wood, a thread of textile, a powder of tooth enamel; all will be rigorously analyzed. The process could take a decade.

That's without any additional materials. Early Mustang, it's thought, was ruled by powerful kings. With so many exposed caves and an unknown number of hidden crypts, far more remarkable troves may be awaiting discovery. "It could be in the next cave we visit," says Aldenderfer. "It could be in a hundred more caves." Indeed, as the team finished their work in Samdzong, there was one more find. Walking across the cliff top after removing the rebar anchors, Hesser came across a distinct, unnaturally round depression in the gravel. Very likely, he had stumbled upon the entrance to another shaft tomb—this one still plugged, its contents sealed within.

The team's travel permit was set to expire; they had a long journey ahead of them. There was little choice but to let this pass by. At least for now. As ever in Mustang, the cliffs hold secrets yet to be uncovered. □

# ONCE UPON A HOME

*There were some charming*
*cottages in Finland.*
*The people moved away.*
*And the animals moved in.*

PHOTOGRAPHS BY KAI FAGERSTRÖM

It was the air of desolation that drew Kai Fagerström to the handful of derelict dwellings near his family's summer home in rural Suomusjärvi, Finland. As the amateur photographer peered through broken windows and cracks in doors, he noticed tiny tracks: Mice, badgers, and other feral trespassers had made themselves at home after the residents had died or relocated. "When I go into these houses, it's like stepping back in time—the past lingers in the corners," says the 48-year-old, who works by day managing properties for a parish in his hometown of Salo. "But there's consolation in the idea that nature is reclaiming the places it has lent to people." *—Carolyn Butler*

NGM MAPS

*Exploring a ramshackle cottage (above)—left vacant after a fire killed its elderly owner—sparked Fagerström's decadelong quest to document his wild new neighbors, including this red squirrel. The project culminated in* The House in the Woods, *a book published in Finnish, German, and English.* Preceding pages: *A fox pup peeks out from a cat door in a dilapidated shed.*

*On a summer night a family of badgers file into the kitchen from a tunnel they dug under the fireplace. It took four years before Fagerström finally caught the skittish, nocturnal weasels. For this shot he set his camera on a windowsill, then stood outside on a ladder for hours before pressing the shutter via remote control.*

*Typically, Fagerström envisions an image, then plans the photo shoot. He'll set his camera at the perfect angle, throw out peanuts as bait, and wait for wildlife to wander into the picture frame. "Sometimes you get lucky, but often it takes all night," says the photographer, who has to adjust his settings for natural light since he doesn't even own a flash. He spent several evenings waiting to capture his dog staring down a bank vole as well as the squirrel poking around a door. Every so often a shot is pure happenstance. A pygmy owl flew in through a smashed window, surprising Fagerström: "He looked at me and sort of stamped his foot, as if to say, Go away, this is my place!"*

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Whipping wind, floods, avalanches, and earthquakes take center stage in this National Geographic Channel series. Find out what it takes to withstand weather at its worst as scientists simulate natural disasters and record their effects on specially constructed buildings (like this house in Toronto, left). Joplin, Missouri, residents contribute personal accounts of surviving a catastrophic tornado.

### LECTURE

**KENNY BROAD** The environmental anthropologist (left) was named a National Geographic Explorer of the Year in 2011 for his daring explorations of submerged caves. Listen to his tales from the depths, and learn about his research on freshwater resources. For speaking dates in Canada and the U.S. go to *nglive.org*.

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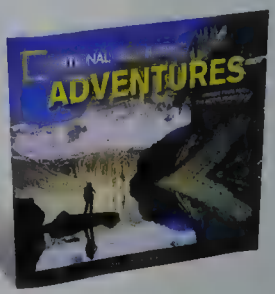


### EXHIBIT

**DESERT AIR** To photograph the desert from above, George Steinmetz piloted a motorized paraglider. See his work at the National Geographic Museum; visit *ngmuseum.org* for details.

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**This Grammy Award-winning, ten-piece band is back with a new album recorded live in the members' hometown of Austin, Texas. Get a taste of their signature combination of salsa, *cumbia*, and mambo—which heats up against a backdrop of funk and jazz—by downloading a free song at *natgeomusic.net/free*.**



PHOTOS: PIONEER PRODUCTIONS (HOUSE); WES C. SKILES (KENNY BROAD); YOURI LENQUETTE (GRUPO FANTASMA)

# Big Fish, Little Fish

Trapped under ice, lost at sea, chased by sharks—Brian Skerry has had more than a few scares in 35 years of photographing underwater wildlife. This close encounter with a whale shark was quite the opposite. Snorkeling off Mexico's Yucatán Peninsula, amid some 400 of the world's biggest fish, Skerry spotted a massive maw coming at him with a remora darting around inside the giant filter feeder. "It's not something the shark would eat," notes Skerry of the suckerfish. Neither is he. Nonetheless, he quickly moved out of the way. *—Luna Shyr*

BEHIND THE LENS

## Were you scared to be in the path of a 30-foot whale shark?

**BS:** Fear is a good thing when working with wild animals. Whale sharks aren't harmful to people. The worst thing is you might get bumped by one, but it's not like a bluefin tuna swimming like a torpedo at 60 miles an hour. This thing is moving very slow and steady, kind of just mowing the grass, so my only concern was that I would bump it and somehow bother it.

**What's unusual about this picture?**

Sharks are near and dear to my heart, and this is a view that many people don't get to see. I saw behavior in this area I'd never seen before: several hundred whale sharks all feeding right at the surface of the water. It blew me away. It's pretty rare to see more than one animal at a time.

**Wouldn't it have been safer to use a telephoto lens?**

Underwater photographers don't always have the luxury of using them. We have to get very close to our subjects to capture color and details because the water refracts and scatters light. I never cease to be amazed how these animals allow us into their worlds.

**Parade Float** "This kitten, perhaps, is wondering how he is going to get ashore without wetting his feet," opines the note accompanying a 1935 Alfred T. Palmer photo from the Philippines. "But he is perfectly safe so long as he stays aboard this floating giant of the vegetable world, the 'Queen Victoria' *(Victoria regia)* water lily."

The tiny cat's perfect safety wasn't ever in question. Now more commonly called the giant water lily—reaching eight feet across and staying afloat by means of a substantial amount of air trapped in the spaces between its ribs—the plant is strongest at its center and can hold up to a hundred pounds. *—Johnna Rizzo*

**Flashback Archive** Find all the photos at **ngm.com.**

PHOTO: ALFRED T. PALMER, NATIONAL GEOGRAPHIC IMAGE COLLECTION

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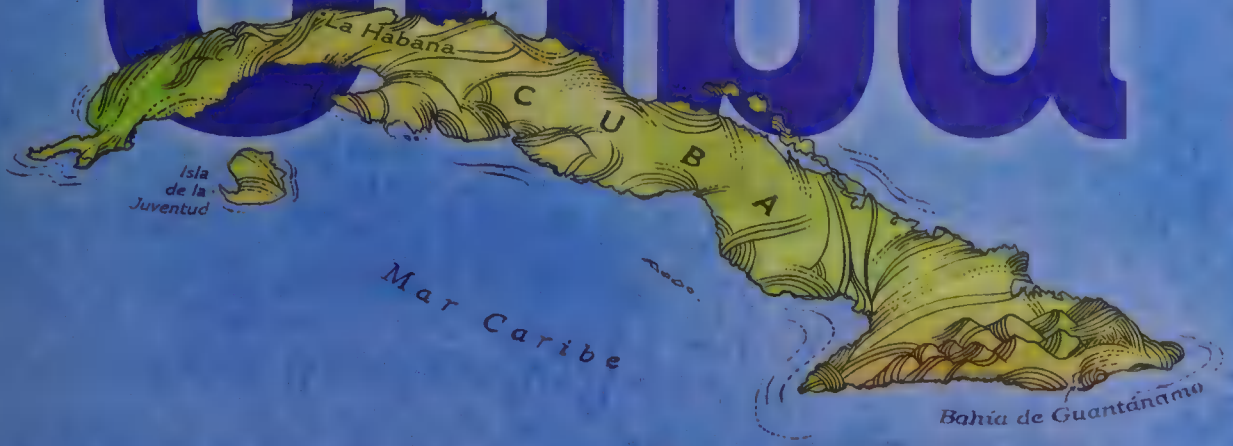
moving forward

POSTER
World's Fastest Runner

NOVEMBER 2012

# NATIONAL GEOGRAPHIC

# Cuba




## ON THE EDGE OF CHANGE

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VOL. 222 ▪ NO. 5

# NATIONAL GEOGRAPHIC

*"I spotted a pair of women's shoes on a porch... covered in ruby red glitter."*
page 133

PAUL NICKLEN

Lumbering on land, emperor penguins are Olympian swimmers, capable of diving to 1,750 feet and remaining underwater 20 minutes on a single breath.

## *November 2012*


28 **Cuba's New Now**
The people respond to reforms with excitement, black humor, and a large dose of skepticism.
*By Cynthia Gorney Photographs by Paolo Pellegrin*

60 **It's All in the Bubbles**
No one knew how emperor penguins could rocket through the water so fast. Now scientists have discovered the secret.
*By Glenn Hodges Photographs by Paul Nicklen*

80 **Vikings and Native Americans**
Strange strands of yarn are helping uncover a lost chapter of New World history.
*By Heather Pringle Photographs by David Coventry*

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110 **Cheetahs on the Edge**
They're shy and delicately built. They can't roar. But the threatened cat is a shrewd survivor.
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124 **Arkansas Delta, 40 Years Later**
A VISTA volunteer, he made black friends, was attacked by whites. Now he and his camera return.
*By Charles Bowden Photographs by Eugene Richards*

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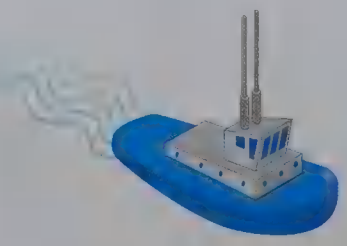
**A Cup Full of Sun**
A three-mile-wide cup in space might be the best way to collect solar energy.

**Miraculous Moringa Tree** ▸
It resists drought, grows like a weed, has leaves packed with vitamins.

**Little Horse, Big Bite**
The four-foot-tall konik is better than a chain saw at cutting back brush.

**Leech Census**
Trying to track an elusive species? Check the DNA in a leech's blood meal.

**California Cleaning** ▸
Find out what it took to green up the Golden State's largest ports.



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Scientists feed ice water to subjects to see why cold can make your head hurt.

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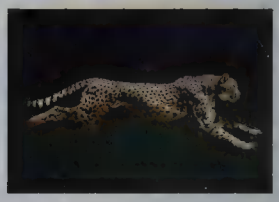
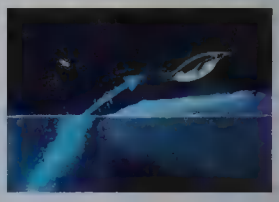
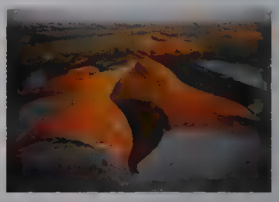


**Cheetahs**
Video
*See the planet's fastest runner in slow motion.*



**Emperor Penguins**
Video +
Interactive Graphic
*Learn how their feathers speed them along.*



**Sand Dunes**
Video
*Join the photographer as he flies over the desert.*

**On the Cover** *Map by Jeremy Collins. Cheetah photo by Ken Geiger, NGM Staff*

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# Fast-Forward and Replay

I first saw the explosion of speed on the Serengeti Plain 24 years ago. With astonishing swiftness, the cheetah closed the gap between predator and prey, then lay beside the struggling Thomson's gazelle with her jaws around his throat. I wanted a slow-motion replay to document that speed.

Thirteen years later I tried for one on a grassy flat in Namibia. Laurie Marker of the Cheetah Conservation Fund had raised a cheetah she'd named Chewbaaka. To keep him fit, she'd trained him to chase a lure. Photo engineer Kenji Yamaguchi and I set up a dozen cameras programmed to fire eight frames a second in sequence. For more than a week Chewbaaka chased the lure. The results were disappointing. The cat did his job, but we didn't have the technology to do ours. This summer, with the help of National Geographic's Big Cats Initiative and Darlene and Jeff Anderson, we tried again. The Cincinnati Zoo offered its cheetahs, and cheetah guru Cathyrn Hilker offered her expertise. A crew of Hollywood's best set up a 400-foot-long track with a remote-control sled to keep pace with each cat. On the sled were a high-def digital cinema camera firing off 1,200 frames a second and three cameras shooting 42 frames a second in sequence. A 150,000-watt light illuminated the course. For three days the cheetahs did their job, but the results fell short of expectations. Finally, the last night, everything clicked. In this month's issue and on our app, you'll see these images of the fastest runner on Earth, inspired by a Serengeti cheetah 24 years ago.

Cincinnati Zoo cheetah Tommy T—a young male—takes a nighttime run.

**Tonkin Snub-nosed Monkey** *(Rhinopithecus avunculus)*
**Size:** Head and body length, 50 - 65 cm (19.7 - 25.6 inches); tail, 65 - 92 cm (25.6 - 36.2 inches) **Weight:** Males approx. 14 kg (30.9 lbs); females approx. 8.5 kg (18.7 lbs) **Habitat:** Lowland tropical broadleaf monsoon forests in montane limestone formations **Surviving number:** Estimated at 260

*Photographed by Quyet Le Khac*

# WILDLIFE AS CANON SEES IT

Phantom of the forest. Once presumed extinct, the Tonkin snub-nosed monkey reappeared in 1989 like a ghost from the past and today clings to a precarious existence in a few isolated locations. Large, semi-cohesive bands of 25-80 individuals are organized around family groups, all ranging and resting together. Active during the day, they move through the trees searching out edible leaves, fruits and seeds. When hunted, bands split into smaller units. But with their habitat being lost or disturbed at an alarming rate, it's becoming harder and harder to vanish into the forest and leave the hunters behind.

As we see it, we can help make the world a better place. Raising awareness of endangered species is just one of the ways we at Canon are taking action—for the good of the planet we call home. Visit **canon.com/environment** to learn more.

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# Easter Island

If the *moai* could talk, they would probably talk about one of the most important guys on any construction team after the foreman: the halfway-intelligent lazy guy. After all the dragging, walking, skidding, and all the broken statues lying by the wayside, this guy would figure out an easier way. He would have seen they were on a hillside, so why not cut them into round cylinders and roll them down the hillside. Then the problem goes from moving them to just stopping them. And the carving guys could have finished them in place.

**JOE RIP**
**Bellingham, Washington**

Last year we were on a cruise ship that stopped at Easter Island but couldn't land its passengers because the waves were too high. We could see many buses lined up at the harbor and estimated that the local tourist industry lost significant revenue that morning alone. We were told by the crew that this happened more often than not. They rated the chance of getting ashore from a cruise ship as low as one in four. The Chilean government needs to upgrade the harbor to increase tourist dollars not only to support the local economy but also to have more funds to preserve the monuments.

**DAVID AND SUSAN JACKSON**
**Dundas, Ontario**

Unmentioned in your article is the invasion of non-native plants that are overrunning the land except in parklands managed for tourism. When this is coupled with the overpopulation of horses, the future of Easter Island is not encouraging. Will this be yet another "ecological catastrophe" for this island?

**LINDA C. CORK**
**Palo Alto, California**

The unanswered question is: How did the Rapanui stand the moai upright? They would have little problem rolling the moai to their assigned beaches. But without shipboard rigging, they would not be able to right the toppled ones. Once they got to the beach, the moai could have been tilted over a small cliff, then "walked" into position.

**ROBERT HOUSTON**
**Torrance, California**

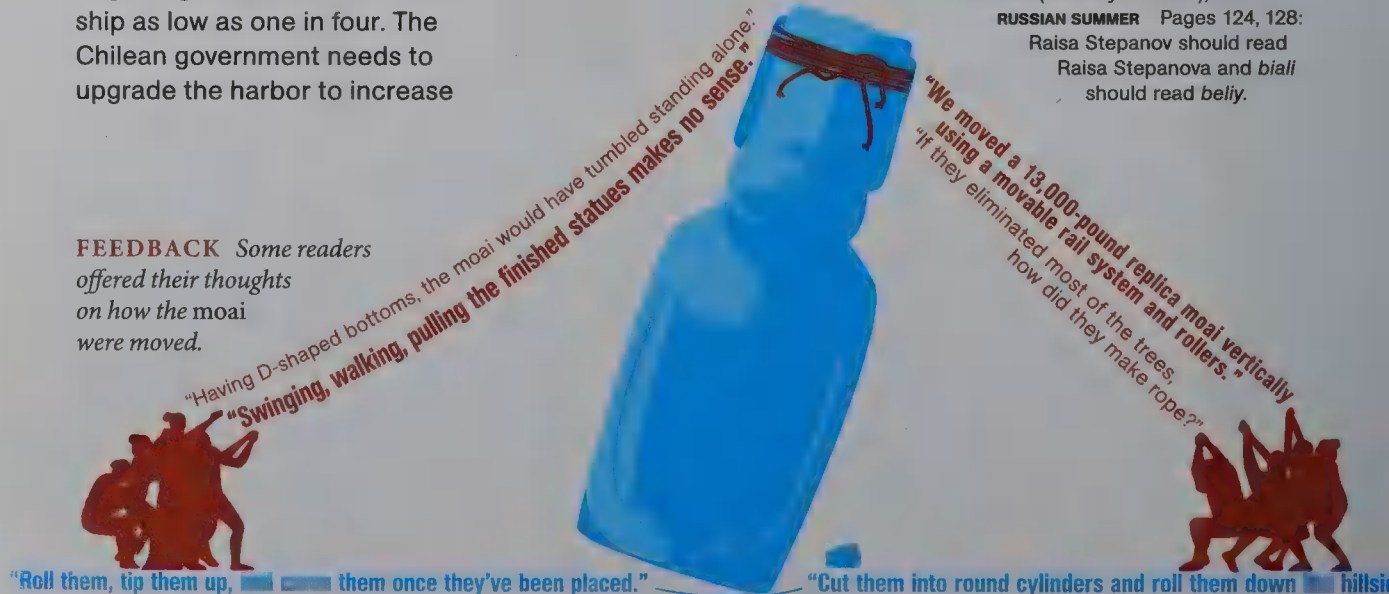
**Corrections**

**JULY 2012: EASTER ISLAND** Page 39: Pavel Pavel's 1986 statue-moving experiment did not damage the moai's base. Damage occurred in his 1987 experiment with a replica.

**VANISHING VOICES** Page 70: *Tradzy* necklaces are worth up to seven mithan (Himalayan cattle), not two.

**RUSSIAN SUMMER** Pages 124, 128: Raisa Stepanov should read Raisa Stepanova and *biali* should read *beliy*.

**FEEDBACK** *Some readers offered their thoughts on how the* moai *were moved.*


"Having D-shaped bottoms, the moai would have tumbled standing alone."
"Swinging, walking, pulling the finished statues makes no sense."
"We moved a 13,000-pound replica moai vertically using a movable rail system and rollers."
"If they eliminated most of the trees, how did they make rope?"
"Roll them, tip them up, them once they've been placed."
"Cut them into round cylinders and roll them down hillsi

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GRAPHIC: JOSHUA MAXWELL

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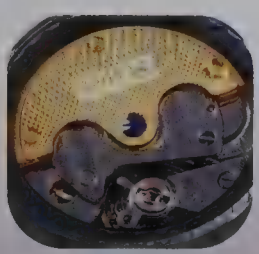

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The Earth's growing population and limited resources mean that innovative ideas are critical to create solutions for energy conservation, generation, and distribution. National Geographic, in partnership with Shell, launched **The Great Energy Challenge** to explore these issues and provide a forum where innovation can be showcased and shared. Go to **GreatEnergyChallenge.com** to join the conversation.

# A WORLD OF INNOVATION: Energy Ideas Around the Globe

## ENERGY NEWS AND ENERGY BLOGS

Stay updated on the future of fuel and power with **Energy News** and **Energy Blogs** written by experts. Check out these stories below from around the world, and add your voice to discussion threads.

*Turning Torso in Western Harbour, Malmö, Sweden*

Formula One Legend Sets Course for Energy-Efficient Car Design
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MALMÖ, SWEDEN
India Power Outage Spotlights Energy Planning Failure
MUMBAI, INDIA
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A $200,000 reen Home Designed by Frank Gehry
CENTRAL UGANDA
Low-Cost Solar Brightens Lives in Developing World
SINGAPORE
Singapore's "Zero Energy Building" is a Test Bed for Green Building Innovations

## THE GREAT ENERGY CHALLENGE GRANTEE SPOTLIGHT

**EARTHSPARK INTERNATIONAL IN HAITI. Seventy percent of Haitian households currently lack access to grid electricity.** The Great Energy Challenge grantee EarthSpark International is launching Haiti's first pre-pay micro-grid that will provide affordable, reliable, and sustainable electricity to 40 paying customers. The grid will be scalable to serve all of downtown Les Anglais and to interconnect with any grid extension that ultimately reaches the area. Moreover, the grid will be replicable: within five years, hundreds of small towns could gain access to locally generated power.

NATIONAL GEOGRAPHIC

A NATIONAL GEOGRAPHIC INITIATIVE IN PARTNERSHIP WITH SHELL

**Be a part of the solution; take part in the challenge.**
**Go to GREATENERGYCHALLENGE.COM to learn more about and contribute to the world's energy solutions.**

# VISIONS

**Saudi Arabia.** Flooded with light at dusk, signals the near end of daylong fasting, Mecca's Great Mosque brims with Muslims performing the *umrah* pilgrimage during Ramadan. As with the sacred hajj, they circle around the cube-shaped Kaaba, Islam's holiest site.

PHOTO: AMER HILABI, AFP/GETTY IMAGES

**Spain**
Heat engulfs a horse—dampened to prevent burning—as it races through a bonfire during Las Luminarias de San Antón in San Bartolomé de Pinares. The ritual, held the night before a festival for blessing animals, is thought to purify horses.

PHOTO: JASPER JUINEN, GETTY IMAGES

**Romania**
On a rural stretch near Odobesti, a teenager sets off at dawn to saw logs at the homes and farms of local residents. Wintertime brings demand in the area for woodcutters' help in preparing fuel for heating and cooking.

PHOTO: [illegible]

Order prints of *National Geographic* photos online at **PrintsNGS.com**.

This page features two photographs: one chosen by our editors and one chosen by our readers via online voting. For more information, go to *ngm.com/yourshot*.

**EDITORS' CHOICE** **Cesar Aristeiguieta** Santa Monica, California

Watching captive wolves on a ranch in Kalispell, Montana, Aristeiguieta witnessed a young male (left) challenge the alpha male. "Despite tense and dangerous moments, the handlers were able to separate them," reports the photographer, 51, who's also a physician.

**READERS' CHOICE**

**Colleen Pinski**
Peyton, Colorado

Pinski, 28, and her husband drove several hundred miles to Albuquerque just to get a better view of an annular solar eclipse. "We're avid adventurists, so we couldn't pass up the opportunity," she says. A supertelephoto lens helped secure a larger-than-life image.

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At Boyoma Falls in the Democratic Republic of the Congo, villagers atop scaffolds check their baskets for fish.

**The Cataracts** In the Democratic Republic of the Congo, on a turbulent 60-mile stretch of the Lualaba River, a timeless ritual plays out. The Wagenia people use vines to lower wooden baskets from scaffolding and snare fish in the rapids of Boyoma Falls. It's the same method used by their ancestors, the same one described by the explorer Henry Morton Stanley in 1877.

I've always been driven to photograph people whose unique way of life hasn't been well documented. I learned about the Wagenia in 2008, when I saw a billboard in Kinshasa. Two years later I went to "the Cataracts" to watch them fish for food to sell at market.

When the river is shallow, they use wood from the local forest to build stable structures over the falls. They cram tree trunks into riverbed crevices, then craft funnel-like, bark-bound baskets to catch fish driven by the current. It's exhilarating to see them clamber calmly above the torrent or wade through it over glass-slick rocks.

But the biggest thrill is the chance to step back in time. In a region marked by turmoil, there's one place—and practice—still untouched.

THE PHOTOGRAPHER

*See more of Andrew McConnell's work at* andrewmcconnell.com.

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With a small fish in his mouth and a giant one in his hands, a Wagenia villager harvests the Lualaba River. Every day I was there I ate delicious fish—tiger fish, catfish, perch, and more—often cooked in banana leaves with chili and palm oil.

The Wagenia learn to fish at an early age. Young girls (like the one at left) use nets in the small rapids. Boys emulate their fathers, building miniature baskets and working in the shallows. For shots like this I covered my camera in a waterproof housing.

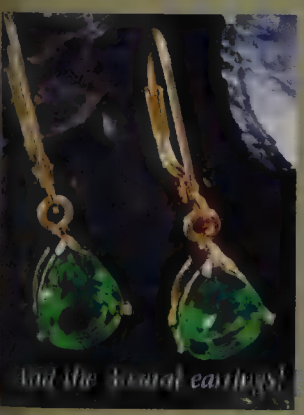
Limited to the first 2500 respondents

# The Beauty in the Beast

For almost a hundred years it lay dormant. Silently building strength. At 10,000 feet high, it was truly a sleeping giant, a vision of peaceful power. Until everything changed in one cataclysmic moment. On May 18, 1980, the once-slumbering beast awoke with violent force and revealed its greatest secret.

It was one of nature's most impressive displays of power. Mount St. Helens erupted, sending a column of ash and smoke 80,000 feet into the atmosphere. From that chaos, something beautiful emerged... our spectacular ***Helenite Necklace***. Produced from the heated volcanic rock dust of Mount St. Helens, this brilliant green creation has captured the attention of jewelry designers worldwide. Today you can wear this 6½-carat stunner for the exclusive price of only $129!

**Your satisfaction is guaranteed.** Our ***Helenite Necklace*** puts the gorgeous green stone center stage, with a faceted pear-cut set in gold-layered .925 sterling silver. The explosive origins of the stone are echoed in the flashes of light that radiate as the piece swings gracefully from its 18" gold-plated sterling silver chain. Today the volcano sits quiet, but this unique piece of natural history continues to erupt with gorgeous green fire.

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At the seventh and last cataract of Boyoma Falls—the point where the raging Lualaba River becomes the Congo—a fisherman braves slippery rocks and a strong current to check his basket.

# DIABETES DAMAGES NERVES

## which may cause shooting, burning, pins-and-needles pain.

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*Individual results may vary. †Those who have had a drug or alcohol problem are more likely to misuse Lyrica.

**Prescription Lyrica is not for everyone.** Tell your doctor right away about any serious allergic reaction that causes swelling of the face, mouth, lips, gums, tongue, throat or neck or any trouble breathing or that affects your skin. Lyrica may cause suicidal thoughts or actions in a very small number of people. Call your doctor right away if you have new or worsening depression, suicidal thoughts or actions, or unusual changes in mood or behavior. Lyrica may cause swelling of your hands, legs and feet. Some of the most common side effects of Lyrica are dizziness and sleepiness. Do not drive or work with machines until you know how Lyrica affects you. Other common side effects are blurry vision, weight gain, trouble concentrating, dry mouth, and feeling "high." Also, tell your doctor right away about muscle pain along with feeling sick and feverish, or any changes in your eyesight including blurry vision or any skin sores if you have diabetes. You may have a higher chance of swelling, hives or gaining weight if you are also taking certain diabetes or high blood pressure medicines. Do not drink alcohol while taking Lyrica. You may have more dizziness and sleepiness if you take Lyrica with alcohol, narcotic pain medicines, or medicines for anxiety. If you have had a drug or alcohol problem, you may be more likely to misuse Lyrica. Tell your doctor if you are planning to father a child. Talk with your doctor before you stop taking Lyrica or any other prescription medication.

*Please see Important Risk Information for Lyrica on the following page.*

**To learn more visit www.lyrica.com or call toll-free 1-888-9-LYRICA (1-888-959-7422).**

***You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.FDA.gov/medwatch or call 1-800-FDA-1088.***

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# IMPORTANT FACTS

LYRICA® PREGABALIN © capsules (LEER-i-kah)

## IMPORTANT SAFETY INFORMATION ABOUT LYRICA

LYRICA may cause serious, even life threatening, allergic reactions. Stop taking LYRICA and call your doctor right away if you have any signs of a serious allergic reaction:

- Swelling of your face, mouth, lips, gums, tongue, throat or neck
- Have any trouble breathing
- Rash, hives (raised bumps) or blisters

Like other antiepileptic drugs, LYRICA may cause suicidal thoughts or actions in a very small number of people, about 1 in 500.

Call your doctor right away if you have any symptoms, especially if they are new, worse or worry you, including:

- New or worsening depression
- Suicidal thoughts or actions
- Unusual changes in mood or behavior

Do not stop LYRICA without first talking with your doctor.

LYRICA may cause swelling of your hands, legs and feet. This swelling can be a serious problem with people with heart problems.

LYRICA may cause dizziness or sleepiness. Do not drive a car, work with machines, or do other dangerous things until you know how LYRICA affects you. Ask your doctor when it is okay to do these things.

## ABOUT LYRICA

LYRICA is a prescription medicine used in adults 18 years and older to treat:

- Pain from damaged nerves that happens with diabetes or that follows healing of shingles
- Partial seizures when taken together with other seizure medicines
- Fibromyalgia (pain all over your body)

Who should NOT take LYRICA:

- Anyone who is allergic to anything in LYRICA

## BEFORE STARTING LYRICA

Tell your doctor about all your medical conditions, including if you:

- Have had depression, mood problems or suicidal thoughts or behavior
- Have or had kidney problems or dialysis
- Have heart problems, including heart failure
- Have a bleeding problem or a low blood platelet count
- Have abused prescription medicines, street drugs or alcohol in the past
- Have ever had swelling of your face, mouth, tongue, lips, gums, neck, or throat (angioedema)
- Plan to father a child. It is not known if problems seen in animal studies can happen in humans.
- Are pregnant, plan to become pregnant or are breastfeeding. It is not known if LYRICA will harm your unborn baby. You and your doctor should decide whether you should take LYRICA or breast-feed, but not both.

Tell your doctor about all your medicines. Include over-the-counter medicines, vitamins, and herbal supplements. LYRICA and other medicines may affect each other causing side effects. Especially tell your doctor if you take:

- Angiotensin converting enzyme (ACE) inhibitors. You may have a higher chance for swelling and hives.

## BEFORE STARTING LYRICA, continued

- Avandia® (rosiglitazone)*, Avandamet® (rosiglitazone and metformin)* or Actos® (pioglitazone)** for diabetes. You may have a higher chance of weight gain or swelling of your hands or feet.
- Narcotic pain medicines (such as oxycodone), tranquilizers or medicines for anxiety (such as lorazepam). You may have a higher chance for dizziness and sleepiness.
- Any medicines that make you sleepy

## POSSIBLE SIDE EFFECTS OF LYRICA

LYRICA may cause serious side effects, including:

- See "Important Safety Information About LYRICA."
- Muscle problems, pain, soreness or weakness along with feeling sick and fever
- Eyesight problems including blurry vision
- Weight gain. Weight gain may affect control of diabetes and can be serious for people with heart problems.
- Feeling "high"

If you have any of these symptoms, tell your doctor right away.

The most common side effects of LYRICA are:

- Dizziness
- Blurry vision
- Weight gain
- Sleepiness
- Trouble concentrating
- Swelling of hands and feet
- Dry mouth

If you have diabetes, you should pay extra attention to your skin while taking LYRICA and tell your doctor of any sores or skin problems.

## HOW TO TAKE LYRICA

Do:

- Take LYRICA exactly as your doctor tells you. Your doctor will tell you how much to take and when to take it. Take LYRICA at the same times each day.
- Take LYRICA with or without food.

Don't:

- Drive a car or use machines if you feel dizzy or sleepy while taking LYRICA.
- Drink alcohol or use other medicines that make you sleepy while taking LYRICA.
- Change the dose or stop LYRICA suddenly. You may have headaches, nausea, diarrhea, trouble sleeping, increased sweating, or you may feel anxious if you stop taking LYRICA suddenly.
- Start any new medicines without first talking to your doctor.

## NEED MORE INFORMATION?

- Ask your doctor or pharmacist. This is only a brief summary of important information.
- Go to **www.lyrica.com** or call **1-866-459-7422 (1-866-4LYRICA).**

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# America's First Silver Dollar

## *Own the Dollar that helped Win America's Independence!*

Most Americans would expect to see an authentic Revolutionary War treasure from the 1700s only behind glass in a museum. Now, thanks to the discovery of these coins in the centuries-old *El Cazador* shipwreck, you can actually own America's First Silver Dollar!

### Gleaming Silver with a Story to Tell

Struck in the New World between 1772 and 1783 in 90.1% fine silver, these Spanish colonial "8 Reales" were authorized by the Continental Congress upon the recommendation of Thomas Jefferson as America's first official coinage. Widely circulated throughout the 13 Colonies, they were used to help fund the American Revolutionary War and earned the title of "America's First Silver Dollar."

### Larger Than a U.S. Silver Dollar

Accepted as legal tender in the U.S. until 1857, each of these hefty silver dollars weighs 27 grams and is 39 mm in diameter. From Europe to China, throughout the Caribbean, and across the 13 Colonies, these silver dollars were readily accepted for trade due to their heft and high silver value.

### Imagine Who Held These Coins

Each of these amazing silver dollars makes history come alive. Coins like these were spent in taverns by patriots celebrating America's victory over the British in 1783. Was this the coin George Washington tossed across the Potomac River or used to purchase badly needed supplies for his army?

### Certified Historic Shipwreck Silver

Each of these coins has been inspected and authenticated by Numismatic Guaranty Corporation (NGC) and certified to be genuine shipwreck silver from the legendary Spanish Brig of War, *El Cazador*. Each coin is dated from the revolutionary years of our Founding Fathers: 1772–1783 (*dates our choice*)—and has been sonically-sealed in an acrylic holder for preservation.

### Save Over $175!

America's First Silver Dollars with the *El Cazador* shipwreck pedigree are selling nationally for up to $425. Now, thanks to this exclusive shipwreck treasure discovery, we are able to offer these historic coins for just $249 (plus s/h).

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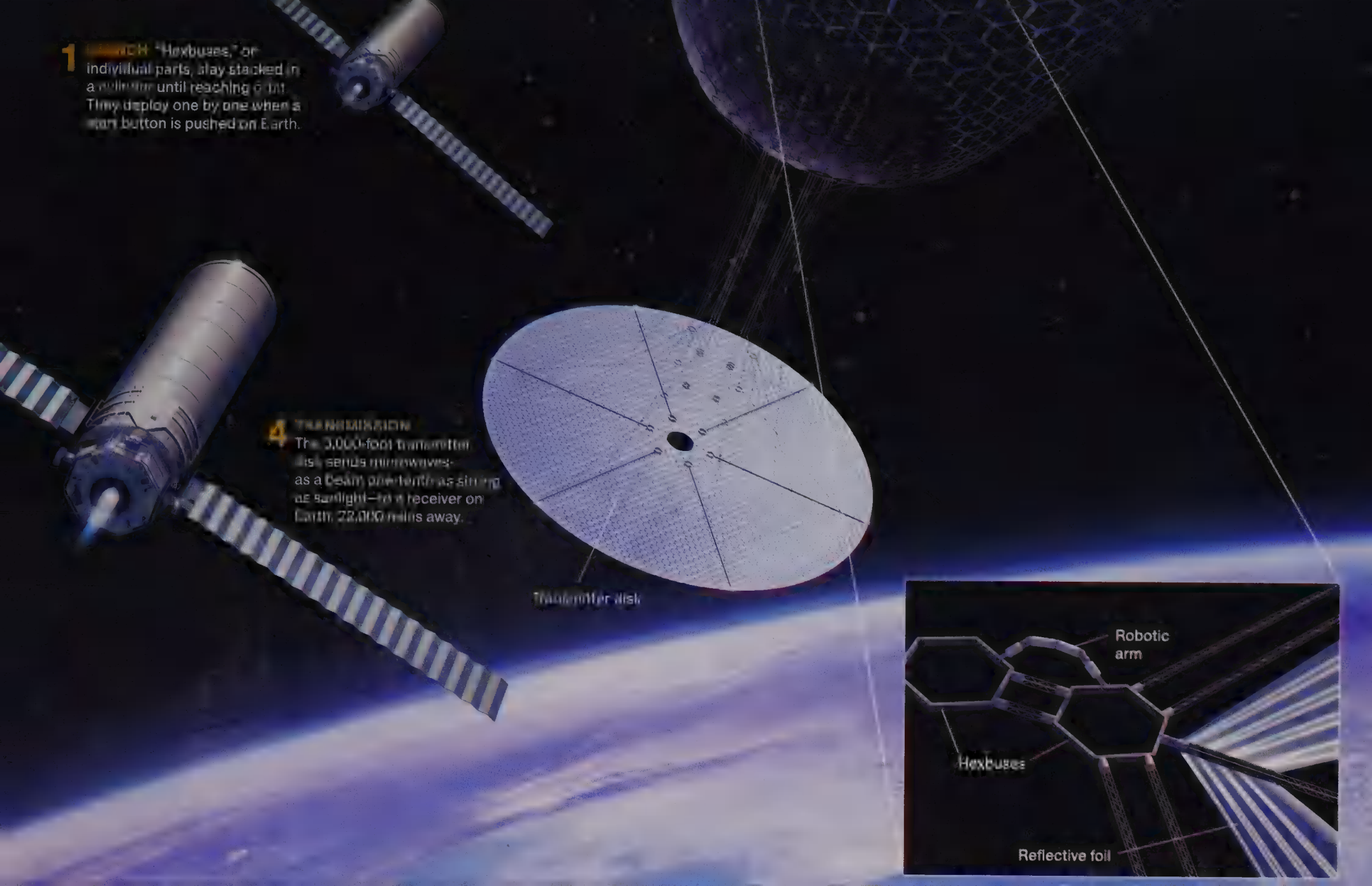
# NEXT

## Tapping the Sun

What's the best way to collect solar energy? Space technologist John Mankins suggests a three-mile-wide space cup, made up of 240,000 movable, self-assembling, replaceable parts. The big benefit of small parts is longevity: If one goes down, it won't take the whole system with it. Send up spare parts, and the energy collector can fix itself. "Every single piece is smart"—a little robot, says Mankins—"so it can say, This is what's wrong with me." NASA, intrigued, accepted Mankins's design into its Innovative Advanced Concepts program.

The space system bypasses deficiencies of earthbound solar collectors. The rays-converted-to-microwaves can pass through any weather; there's no storage problem, because it provides energy on demand; and in space sunlight is in steady supply. Plus the collector's delivery method can reach areas with little energy infrastructure. Though the integrated system hasn't even been built yet, Mankins is optimistic—and thinks as few as three or four could make power accessible to 90 percent of Earth's population. —Jolene Ross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## BASF's Link Between Chemistry and a Sustainable Future

### BASF PRODUCTS IMPROVE WIND TURBINE PERFORMANCE

**DR. JURRON BRADLEY,** MANAGER, CLEAN ENERGY, BASF

"Wind power is a great energy source with the potential to help alleviate concerns about over-reliance on fossil fuels. If you look at the global energy mix, about 2.5 percent of electricity comes from wind, and that is clearly expanding as countries and U.S. states develop mandates to increase use of renewables. Wind energy can be expensive to produce, though, and to help our customers compete successfully, BASF has developed a broad portfolio of solutions, from the rotor blade to the foundation of the turbine.

To protect the blade, BASF provides its customers with a multi-phase coating system called **Relest Wind®** which is based on a unique polyurethane plastic material that guards against humidity and ultraviolet (UV) radiation. BASF also provides a putty that is used to smooth the blade's surface unevenness, as well as topcoat and edge protection to prevent abrasion and deterioration.

Picture a blade that's 130 feet long and zooming at 186 miles per hour: Because of this massive force, high-performance reinforcements, such as fiber-reinforced polymers, are required to construct the blade. To meet this challenge, **BASF's Baxxodur® epoxy systems** bind glass or carbon fibers that form the blade, ensuring lifetimes of at least 20 years and reducing production time up to 30 percent. In the future, **BASF's polyethylene terephthalate (PET)** foam will provide additional stability.

The nacelle, or gearbox, which operates the blades, requires oil changes like a car. Changing the oil is a complicated and expensive procedure. BASF offers **Emgard® transmission oils** and our **ProEco® hydraulic fluid,** both of which allow for longer change intervals and consist of more than 50 percent renewable and biodegradable raw material.

As turbines become taller and blades longer, it's essential to have high-performing materials for the tower and foundation. To meet this need, BASF produces its **Masterflow® 9000 line,** which helps to withstand the heavy, continually changing loads acting on the tower and foundation.

We also have concrete admixtures that aid in the production of strong foundations and tower components. Lastly, BASF supplies coatings for towers that provide excellent corrosion protection.

BASF is committed to developing sustainable solutions for the future. We have projects in the R&D pipeline that will help customers reduce maintenance, improve productivity, and increase energy output, especially as the size of blades grow to the size of a soccer field."

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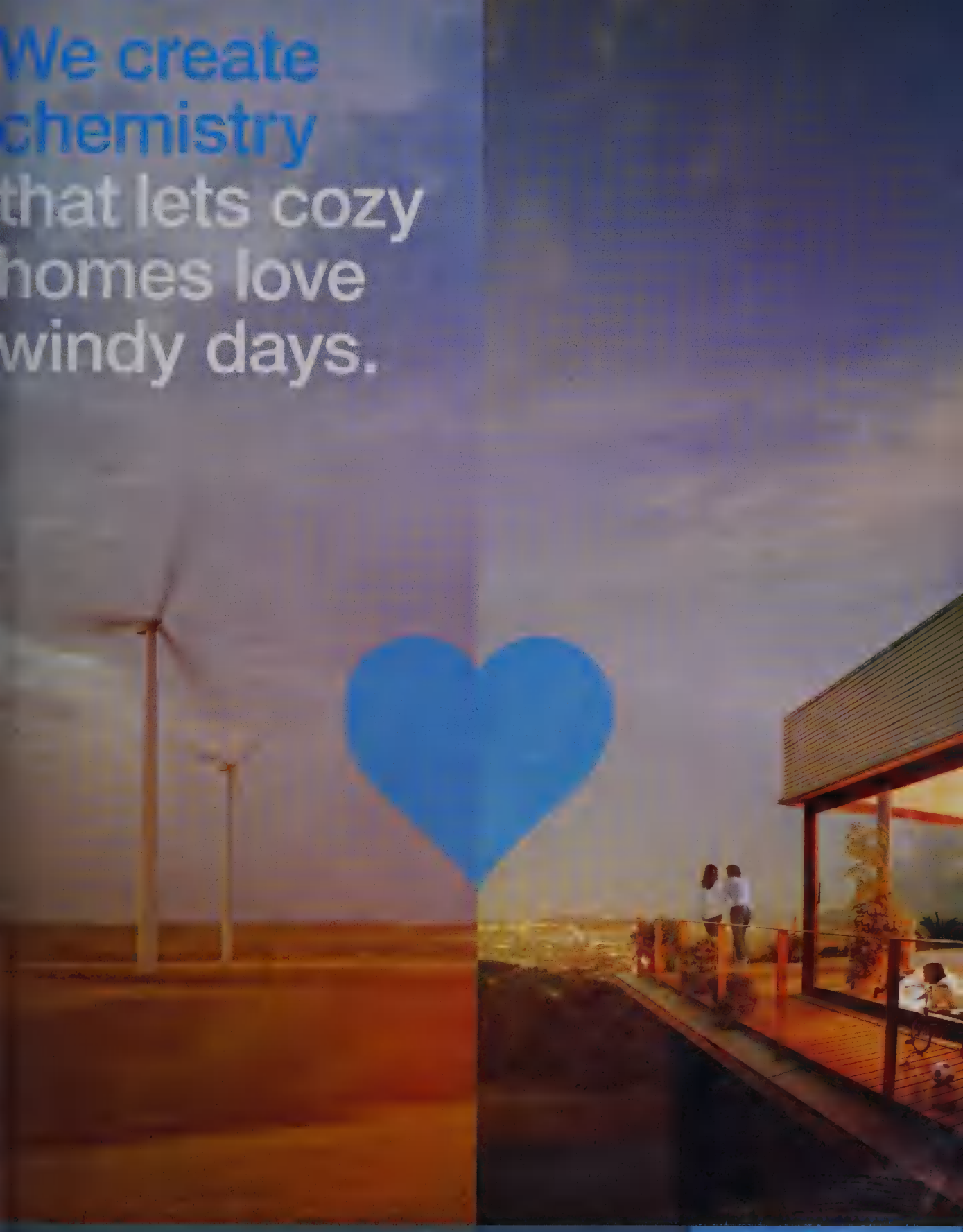


Wind turbines produced with innovative solutions from BASF can withstand high-speed winds and severe weather conditions. Our products help make the production and operation of wind turbines more efficient, as well as making them durable – from the foundations to the very tips of the rotor blades. In this way, we support the development of wind power as a climate-friendly source of energy. When high winds mean clean energy, it's because at BASF we create chemistry.

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## Mighty Moringa

"Mother's best friend," "never die," "drumstick tree"—moringa takes many names around the world. For centuries a traditional remedy for skin, respiratory, digestive, and other ailments, it's now being hailed as a way to battle famine and malnutrition. With vitamin-and-mineral-packed leaves, the drought-resistant tree also grows fast—up to 12 feet in a season.

From spicy seeds to bitter leaves (often ground into a powder), most of *Moringa oleifera* can be eaten or used, says Jed Fahey of Johns Hopkins. Its seeds, crushed, can even help purify water. Although animal studies support anecdotal evidence of its medicinal benefits, more human trials are needed, Fahey notes. Meanwhile, the "miracle tree" is catching on in impoverished areas of Africa, Asia, and Latin America, entering local dishes and lore. *—Luna Shyr*

A native of the Indian subcontinent, the moringa tree has highly nutritious leaves, shaped here from dried leaf powder.

**Gram for gram,** dried moringa leaves have

**25** ■ iron in spinach
**17** × calcium in milk
**15** ■ potassium in bananas
**10** ■ vitamin A in carrots
**9** × protein in yogurt

ART: JENNA TURNER, NGM STAFF. PHOTO: REBECCA HALE, NGM STAFF
CHART SOURCE: LOWELL FUGLIE, *THE MIRACLE TREE: MORINGA OLEIFERA*

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An average forest stores about 100,000 tons of carbon per square mile. Sea grass meadows can hold nearly triple that.

# Horse Power

Diminutive konik horses stand about four feet tall, but they can have a big impact on biodiversity. By eating the woody vegetation that overcomes open marshes, these likely descendants of the horses in prehistoric cave paintings are helping revive the natural landscape that existed when large herbivores roamed freely.

Before Neolithic farmers began to till marshes in what is now Europe, grazers kept forests from creeping in, which allowed varied habitats for birds, insects, and plants to flourish. Today conservationists are trying to revive that diversity. In many places that means cutting brush back with chain saws. But koniks are cheaper and better at it. The horses are now at work in nearly a dozen countries—including some 20 sites in the U.K. alone. *—A. R. Williams*

## Leeches Locate Elusive Species

**Scientists [redacted] out for blood in Vietnam. [redacted] in the blood meal of 14 of 25 leeches came from hard-to-track tropical forest species like the serow—helping biologists monitor mammal diversity (and maybe endangered species) in inaccessible terrain.** *—Lacey Gray*

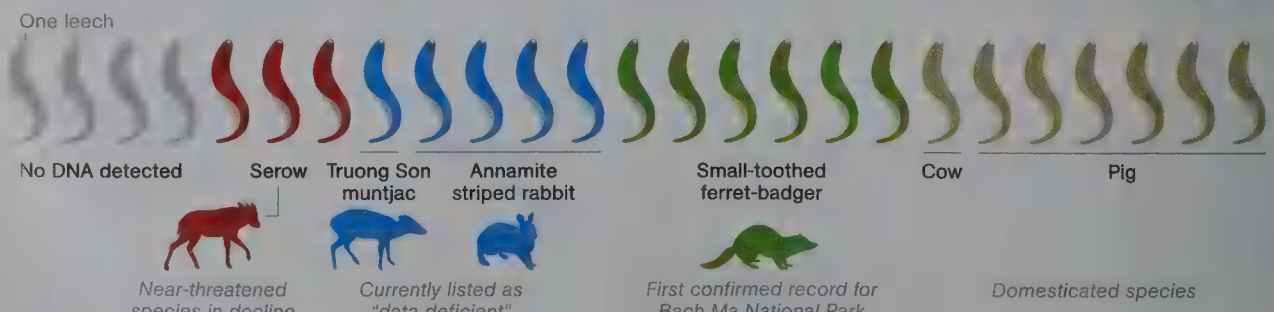
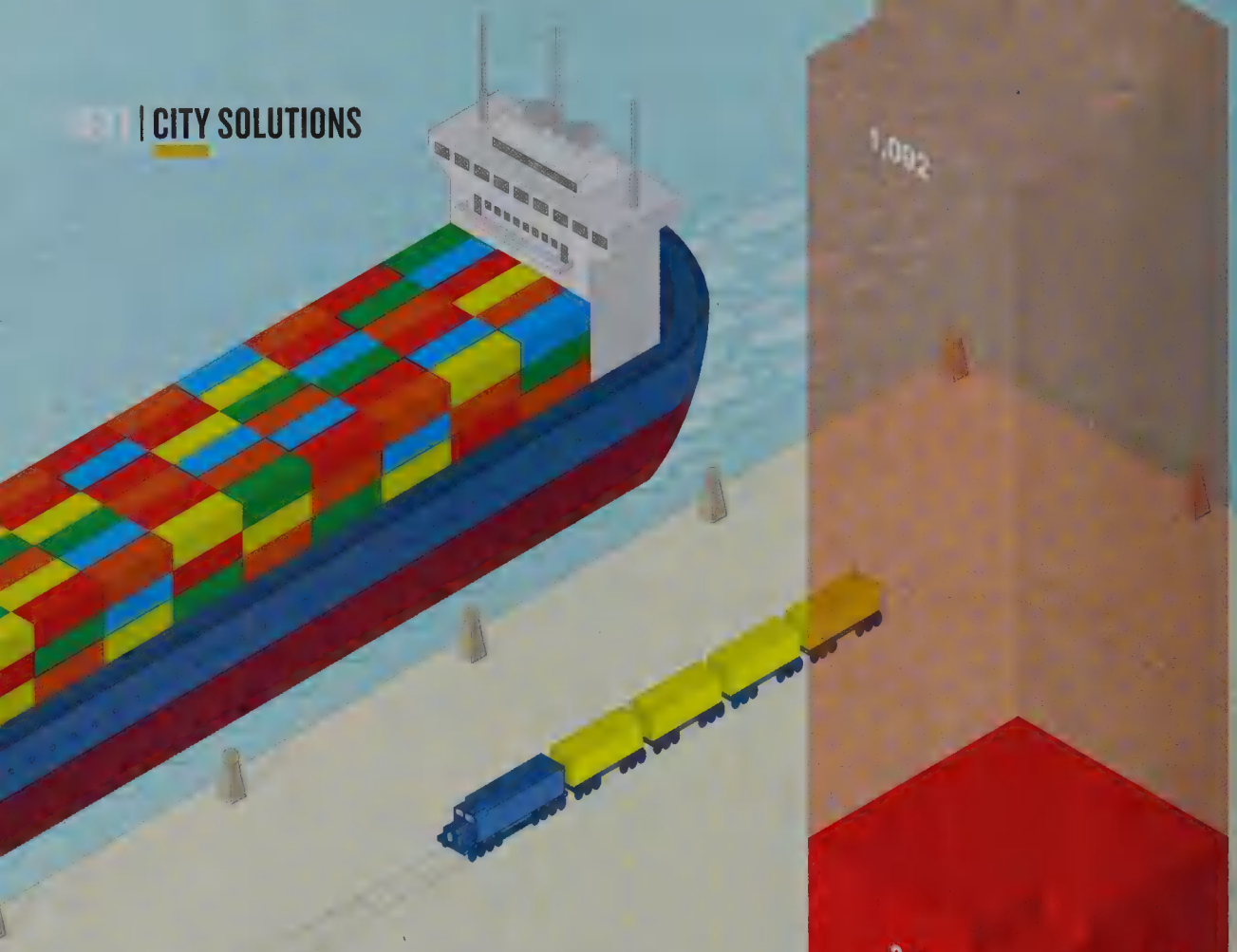
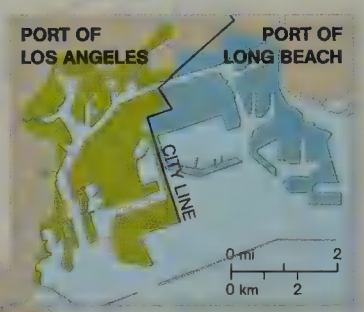


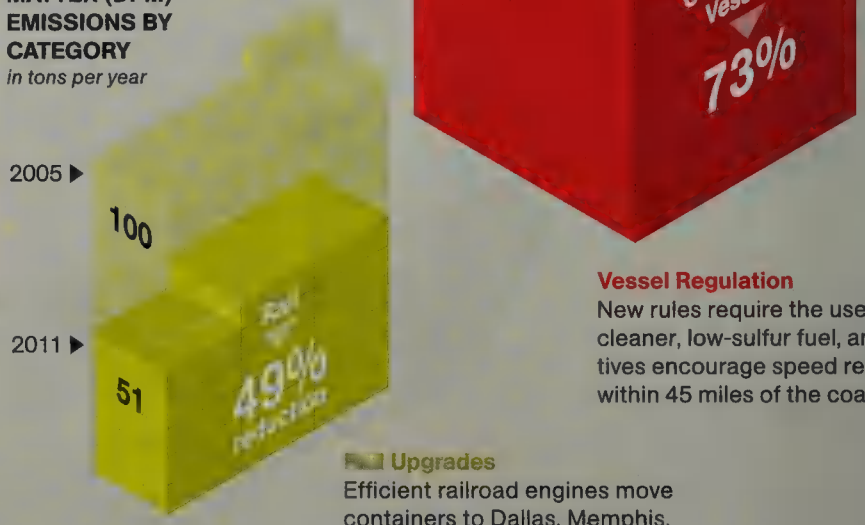

PHOTO: JIM BRANDENBURG, MINDEN PICTURES. GRAPHICS: ÁLVARO VALIÑO (TOP); LAWSON PARKER, NGM STAFF. SOURCE: TOM GILBERT, NATURAL HISTORY MUSEUM OF DENMARK

*Shown with available features.
**EPA-estimated 47 city/47 hwy/47 combined mpg. Actual mileage will vary.






**DIESEL PARTICULATE MATTER (DPM) EMISSIONS BY CATEGORY**
*in tons per year*



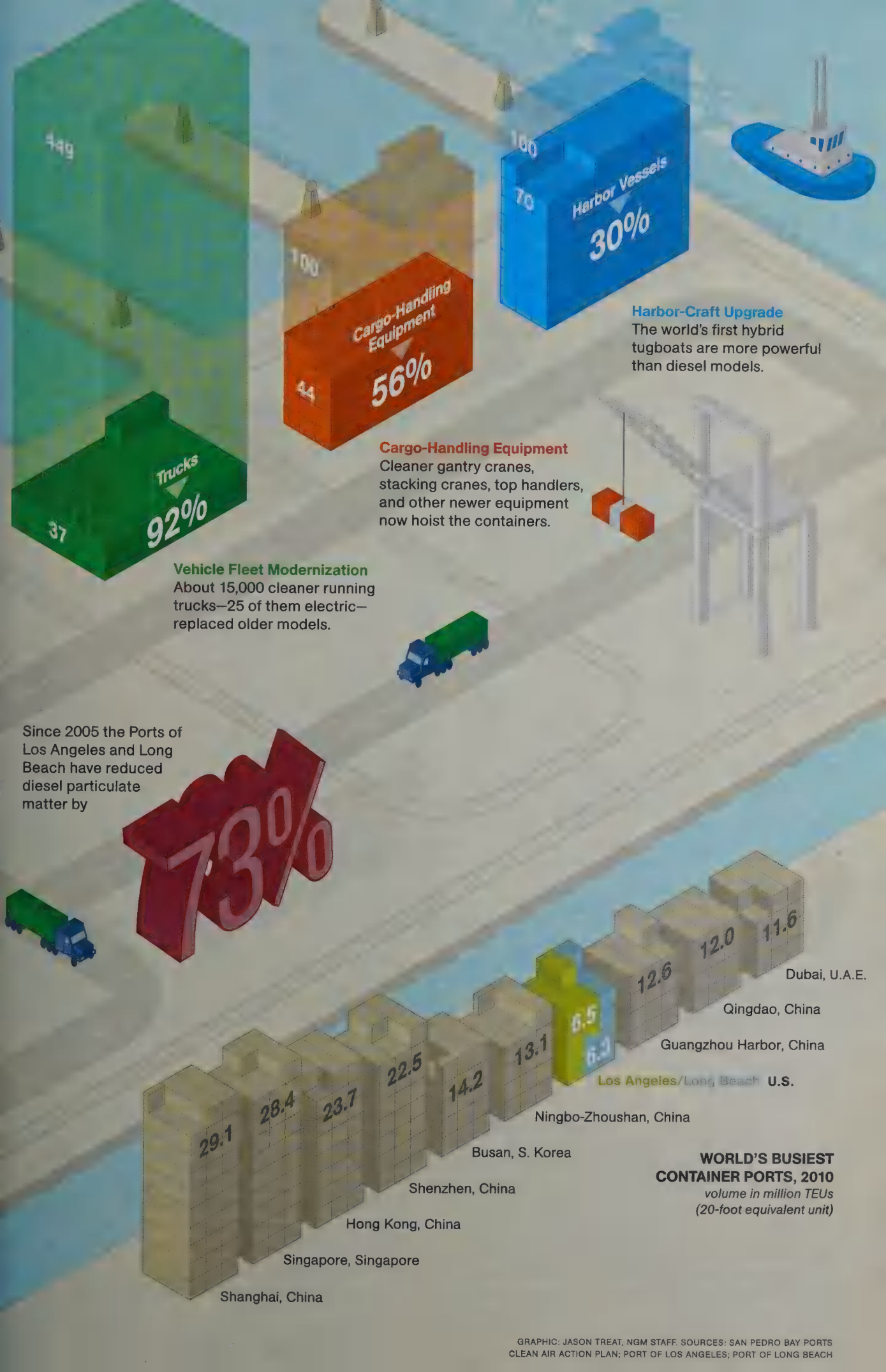

**Vessel Regulation**
New rules require the use of cleaner, low-sulfur fuel, and incentives encourage speed reduction within 45 miles of the coast.

**Rail Upgrades**
Efficient railroad engines move containers to Dallas, Memphis, Chicago, and beyond. The ports are also considering a maglev system.

# California Ports Go Green

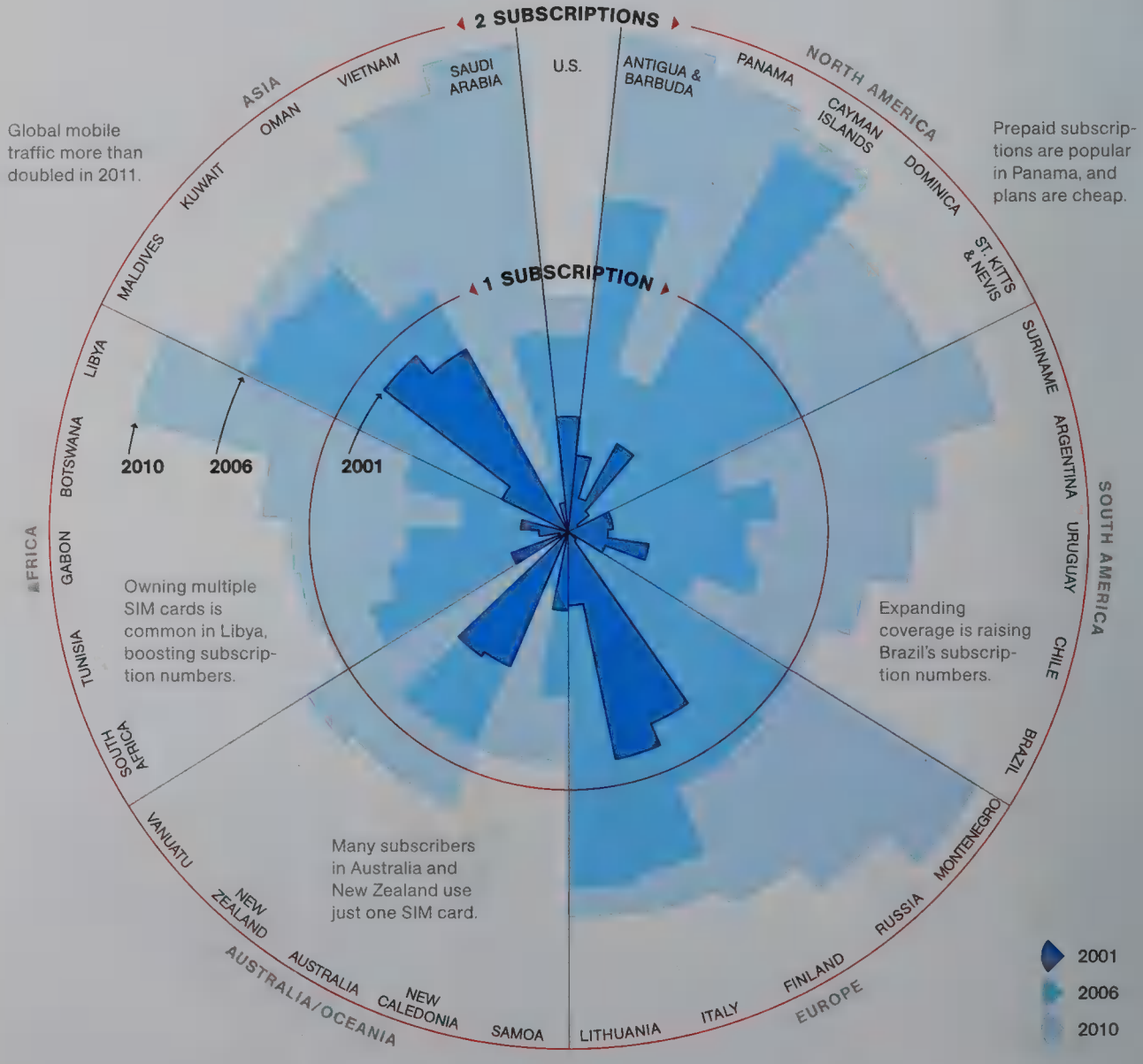
If anything for sale in the U.S. says "Made in China"—furniture, sneakers, auto parts—the odds are fifty-fifty it came through the Port of Los Angeles or the adjacent Port of Long Beach. In 2011 cranes off-loaded nearly 14 million shipping containers holding more than 300 billion pounds of goods (not just from China) and about 14 billion gallons of fuel.

Together L.A. and Long Beach form the largest port in the Western Hemisphere, a nearly 24-square-mile complex of ships, docks, cranes, roads, trucks, and trains so massive it has its own AAA map. Greening it was an equally large undertaking. Replacing machinery, fuels, and infrastructure has reduced harmful pollutants by more than 27,000 tons, and today the port's cleaned-up waters attract sea lions, pelicans, and sharks. *—David Helvarg*




GRAPHIC: JASON TREAT, NGM STAFF. SOURCES: SAN PEDRO BAY PORTS CLEAN AIR ACTION PLAN; PORT OF LOS ANGELES; PORT OF LONG BEACH

**Mobile cellular subscriptions per person**
*Top five countries or territories per continent by year*




# Mobilizing Nations

That gap at 12 o'clock (above) is no mistake. The U.S., where most cell phone plans are postpaid, lags much of the world in mobile subscriptions per person. Subscription rates skew higher where prepaid plans are the norm, because consumers can swap numerous SIM cards—portable memory chips—in and out of one phone to get the best rates for calling, texting, and Internet access. Numbers are often higher in developing nations where landlines are scarce or expensive, says statistician Esperanza Magpantay. Any subscription generating traffic within three months counts as active, she says. Cisco projects the number of mobile devices will top the world's population this year. *—John Briley*

JASON TREAT, NGM STAFF. SOURCES: INTERNATIONAL TELECOMMUNICATION UNION; WORLD TELECOMMUNICATION/ICT DEVELOPMENT REPORT AND DATABASE; WORLD BANK

# Determination is in our nature

Finding oil used to be easy. So was recovering it. Today, oil exploration requires highly specialized skills to deal with the vast challenges we are facing, like unfathomable depths and complicated geology. When we find the oil, it can be difficult to recover due to high pressure and low permeability. And most importantly, we have to meet the world's toughest safety standards - our own. Luckily, we have a secret weapon; our attitude of constantly raising the bar on everything we do. Or as we like to call it - never being satisfied.

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*When exposed to water, fire ants clump together to form a floating raft. Here a raft in its early stages materializes in a laboratory aquarium.*

# Survival Rafting

When floodwaters strike, the fire ant species *Solenopsis invicta* reacts with a clever escape plan: Within minutes colony members link their bodies together to form a water-repellent raft that can stay afloat for weeks. Intrigued, Georgia Tech researchers studied in the lab how the insects, native to South America and now roaming the southern United States, interlock claws, mandibles, and sticky pads on their legs to construct the roughly circular rafts. Air bubbles trapped among the ants' bodies and hairs create buoyancy for the two-tiered structure and enable members on its underside to breathe.

Colonies of as many as 200,000 ants can form rafts measuring up to two feet wide. And in a remarkable feat of swarm intelligence that helps maintain the raft's integrity, ants on the bottom quickly move on top when others succumb to encounters with debris, predators, or swift currents, says researcher Nathan Mlot. Scientists believe that studying this superorganism could provide new insights into micro-robotics and improved water repellency. *—Patrick Graham*

**Raft Dynamics**

1 By grasping one another with jaws, legs, and sticky pads, fire ants form a raft to ride out floods. The raft's rough and irregular shape increases water repellency.

2 On the raft's underside, air bubbles trapped among the bodies create a pocket that enables the ants to breathe and keeps the structure afloat.

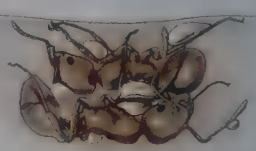

PHOTO: ANAND VARMA. SOURCE: DAVID L. HU AND TIM NOWACK, GEORGIA INSTITUTE OF TECHNOLOGY. ART: SHIZUKA AOKI

An [illegible] will walk about 100,000 miles in a lifetime—the equivalent of [illegible] the [illegible] four times

# Cold Case

Anyone who's ever chugged a chilly drink or eaten ice cream too quickly has felt it: the excruciating pain behind the temples and forehead known as brain freeze. The short-lived condition has long been labeled a physiological mystery. Now research suggests a change in blood flow may be what brings on the icy throb—and perhaps migraines too.

Intrigued by the high rate of chronic headaches he observed at the War Related Illness and Injury Study Center, scientist Jorge Serrador decided to test their origins. The onset of headaches can't be predicted, and he didn't want to prompt them with drugs. So Serrador examined easy-to-induce brain freeze by having participants gulp ice water through a straw aimed at the roof of the mouth. Using a Doppler monitor, Serrador found that just before pain arose, blood flow surged in an artery that feeds the front of the brain. The rush creates pressure in the skull—bringing on the brain freeze. When the artery shrinks back, possibly as the palate warms up again, the reduced blood flow means relief.

Serrador thinks a similar blood flow increase might be the root of migraines and other headaches. As for the torture that next milk shake could trigger? Drink more slowly. —*Catherine Zuckerman*

PHOTO: [illegible]

*After half a century under Fidel, Cubans feel a wary sense of possibility. But this time, don't expect a revolution.*

# CUBA'S NEW NOW

*A window reflects an image of Fidel Castro in a working-class Havana neighborhood few tourists see.*

BEST

*Dog owners prep at Havana's Champion of Champions show. Such flourishes of discretionary spending, a new option for Cubans with the right kind of currency, are a source of both pride and consternation.*

*The century-old stone wall of the Malecón, Havana's famous oceanside esplanade, shields the city—imperfectly—from the battering of roiling seas. On calmer nights people come out to stroll on the street.*

NIPPON

*Markers of a richly Cuban outing at Havana's Parque Lenin: the clicking of dominoes, the head-to-toe white clothing of a Santería adherent, and a Russian sedan likely kept running with transplanted parts.*

*By Cynthia Gorney*
*Photographs by Paolo Pellegrin*

"I want to show you where we're hiding it," Eduardo said.

Bad idea, I said. Someone will notice the foreigner and wreck the plan.

"No, I figured it out," Eduardo said. "You won't get out of the car. I'll drive by, slowly, not so slow that we attract attention. I'll tell you when to look. Be discreet."

He had borrowed a friend's *máquina,* which means "machine" but is also what Cubans call the old American cars that are ubiquitous in the Havana souvenir postcards. This one was a 1956 Plymouth of a lurid color that I teased him about, but I pulled the passenger door shut gently, the way Cubans always remind you to, out of respect for their máquinas' advanced age. Now we were driving along the coast, some distance from Havana, into the coastal town where Eduardo and nine other men had paid a guy, in secret, to build a boat sturdy enough to motor them all out of Cuba at once.

"There," Eduardo said, and slowed the Plymouth. Between two peeling-paint buildings, on the inland side of the street, a narrow alley ended in a windowless structure the size of a one-car garage. "We'll have to carry it out and wheel it up the alley," he said. "Then it's a whole block along this main street, toward that gravel that leads into the water. We'll wait until after midnight. But navy helicopters patrol offshore."

He peered into his rearview mirror at the empty street behind him, concentrating, so I shut up. Eduardo is 35, a light-skinned Cuban with short brown hair and a wrestler's build, and in the months since we first met last winter—he's a former construction worker but that day was driving a borrowed Korean sedan and trying to earn money as an off-the-books cabdriver—we had taken to yelling good-naturedly and interrupting each other as we drove around La Habana Province, arguing about the New Changing Cuba. He said there was no such thing. I said people insisted there was. I invoked the many reports I was reading, with names like "Change in Post-Fidel Cuba" and "Cuba's New Resolve." Eduardo would gaze heavenward in exasperation. I invoked the much vaunted new rules opening up the controlled economy of socialist Cuba—the laws allowing people to buy and sell houses and cars openly, obtain bank loans, and work legally for themselves in a variety of small businesses rather than being obliged to work for the state.

But no. More eye rolling. "All that is for the benefit of these guys," Eduardo said to me once, and tapped his own shoulder, the discreet Cuban signal for a person with military hardware and inner-circle political pull.

What about Fidel Castro having permanently left the presidency four years ago, formally yielding the office of commander in chief to his more flexible and pragmatic younger brother, Raúl?

*"Viva Cuba Libre,"* Eduardo muttered, mimicking a revolutionary exhortation we'd seen emblazoned high on an outdoor wall. Long live free Cuba. "Free from both of them," he said. "That's when there might be real change."

If there is in fact a Cuba under serious transformation—and you can find Cubans all over the country engaging now in their own versions

*A passenger rides shotgun in a Havana taxi—not the kind used by tourists, but one of the geriatric American cars that carry only Cubans, who pay a fraction of the tourist fare.*

of this same debate—Eduardo is a crucial component of it, although not for the reasons you might think. "Dissident" is the right label for a subset of politically vocal Cubans, notably the bloggers whose critical online missives have gained big followings outside the country, but Eduardo is no sort of dissident. He's not fleeing persecution by the state. He's just young, energetic, and frustrated, a description that applies to a great many of his countrymen. Ever since he was a teenager in high school, Eduardo told me, it had been evident to him that adulthood in revolutionary Cuba offered exactly nothing by way of personal advancement and material comfort to anybody except the *peces gordos*. The big fish. (Well, literally translated, the fat fish—the tap-on-the-shoulder parties.) Nothing *works* here, Eduardo would cry, pounding the steering wheel of whatever car he'd hustled on loan for the day: The economic model is broken, state employees survive on their tiny salaries only by stealing from the jobsite, the national news outlets are an embarrassment of self-censored boosterism, the government makes people crazy by circulating two national currencies at once.

"I love my country," Eduardo kept saying. "But there is no future for me here."

Over nine weeks of traveling around Cuba this year and last, I heard this particular sequence of complaints so often, and from so many different kinds of people, that it began to form a kind of collective national lamentation: I love my country and it doesn't work. There were loyal optimists among the complainers, to be sure, and after a while, whenever I encountered one, I found myself marshaling ammunition to bring Eduardo. I wanted to hear how he'd respond, but when I was being honest with myself, I realized that I also wanted to talk him out of the boat. (Sharks swim in those Cuba-to-Florida waters. The currents are dangerous. There are drownings, people never heard from again.)

Optimist: Roberto Pérez, a shaggy-haired environmental biologist, filled with enthusiasm about the progress of Cuba's extensive urban

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*Cynthia Gorney is a contributing writer for the magazine who frequently reports from Latin America. Paolo Pellegrin is a Magnum photographer who lives in Rome and New York City.*

agriculture and organic farming projects. Pérez is six years older than Eduardo. Eighty percent of his own high school graduating class, Pérez told me, has left the country. "But things *are* changing," he said. "Very fast. And there are so many good things here that people take for granted, because they were born with them. You tell me another place where a kid can grow up so safe, get his vaccinations, get his education, not be involved in gangs or drugs. I can see people crossing the river north from Mexico, to get away from that. But from here? To face the Florida strait? I fail to see it."

Still no? OK. Optimist: Josué López, exactly Eduardo's age, just immigrated back to Cuba after six years in Florida and a growing disenchantment with the values of some of his hyper-acquisitive Cuban émigré neighbors in Miami. López and his wife are going into business for themselves, taking advantage of the new self-employment laws and new flexibility in agricultural land use, and developing a bed-and-breakfast resort on a few acres they've acquired outside Havana. "I'm telling my friends who went to the States," López told me, in his practiced slangy English, "Dude! If you want to start something, the place to be is Cuba."

Eduardo would listen, interested, his face sober. He would shake his head. We were arguing in a café one morning, a rooftop spot in the historic part of Havana, and Eduardo grabbed a glass saltshaker from the table. "My whole *life,* the government has been telling us, Look! I'm giving you this nice full saltshaker!" he said. "But it's never full."

This one wasn't either. A half inch of salt, maybe. Eduardo put the shaker down and told me he had gotten hold of some oars. The men would have to row for a while, before they could risk motor noise that might alert authorities; the departure itself would violate Cuban law, since none of them had a *tarjeta blanca,* a white card, the government permission required of all citizens before they may leave the country, even temporarily. Cubans hate the tarjeta blanca, and the government subsequently hinted at doing away with it entirely—but on this early spring morning Eduardo hadn't even applied for one, since he assumed the tarjeta would be denied, as they sometimes are, with no explanation beyond the bland, omnipresent *No está autorizado*—It is not authorized. Besides, a Cuban applying for a tarjeta blanca is supposed to have a visa from the destination country. Just to secure a spot on the consideration list for a U.S. visa, a Cuban must pay $160 and produce a written invitation from some actual person living in the United States.

Eduardo had neither. I had expected him to solicit help from me, the money or the invite, but he never did; he just blurted out the boat plan one day in the middle of a long, talky car ride, as though he'd been desperate for a non-Cuban confessor, and now here we were staring at a saltshaker and brooding about Eduardo's son, who was nine and didn't know his father was going.

"I don't know if it will be better to tell him or worse," he said.

At least the money he'd send home would buy his son new shoes, Eduardo said. "Everything has a risk in life," he said. "I'm not worried. Use my real name. I've told you this before. Use it! I'm not afraid of anybody!" He spread his arms wide, trying to look unworried, and repeated his name the Latin American way: first name, paternal surname, maternal surname. I told him to quit being foolish, that he still lived in a one-party state in which people get roughed up or arrested or excoriated as mercenaries for criticizing their leaders too vigorously, and that we were talking about this in public only because the café waiter was a friend of his and nobody else was nearby. So forget it, I said. Sorry. No real name. We were quiet. Beneath us spread the most famous district in Cuba, the streets the tourists want to see first. There were shining 19th-century tile work, the filigreed top of a Corinthian column, a glimpse of the turquoise sea.

THE WHOLE CITY seemed to be shining, that morning with Eduardo, even though there'd been a *derrumbe* in the neighborhood where I was staying. That's a building collapse, a thing that occurs with some regularity, especially in Havana. Buildings that were once beautiful and

grand are rotting now in the tropical air, and the country has no money to repair them, so they cave in, partially or all at once, a giant rumbling roar followed by rubble and grief. This derrumbe killed four people, three of them teenage girls; the building had been designated unsafe, but Cubans are inventive about their living space in Havana, where parts of the city are so crowded that multiple families and generations wedge into residences that in more decadent eras served as single-family homes. Eduardo had the idea that the number of deaths in my neighborhood derrumbe was 21—he had heard this via *radio bemba,* the radio of lips, which is what Cubans call the word on the street, the only censor-free method for the dissemination of discouraging domestic news. But I had been reading *Granma,* the national Communist Party daily, which to the surprise of many people had actually run articles about this derrumbe rather than pretending it had never occurred and was steadfast about the death toll of four. Anyway, the city looked shiny. The tourists were charging all over by the busload, maps in hand, and from what I could see they appeared to be having a great time, sipping their rum-and-mint *mojitos,* following their multilingual Cuban guides, and applauding the happy cacophony of rumba and *son* that spilled out into the plazas from restaurants and street corners and bars.

Unmistakably, and provocatively, unusual things were transpiring in the streets. In some neighborhoods half the buildings' doorways seemed to have been taken over by new self-employed vendors, the men and women sitting hopefully alongside makeshift displays of hair accessories or homemade pastries or DVDs of movies and television shows. "For Sale" signs, prohibited during the decades when it was legal to exchange residences but not to sell them, now appeared in house windows. In a few weeks Pope Benedict XVI was due to arrive, the first papal visit to Cuba in 14 years. Along the route the papal cortege would follow, state workers were cleaning and painting house facades so assiduously that I heard people joke that they wished the Holy Father would show up more often, just for the urban cleanup.

Hefty half-built structures stuck out here and there—the anti-derrumbes, as I came to think of them, into which the country's sparse investment resources were being directed. High cranes and scaffolding delineated the rehabilitation of historic buildings, the gussying up of tourist destinations, the construction of new port facilities. From certain spots along the shoreline, you could make out the shape of the huge deepwater rig exploring the Cuban seabed, believed to contain billions of barrels' worth of oil. If large-scale oil production is merited, the possibilities for the country's economic future are profound.

**HALF THE BUILDINGS' DOORWAYS SEEMED TO HAVE BEEN TAKEN OVER BY NEW SELF-EMPLOYED VENDORS, THE MEN AND WOMEN SITTING HOPEFULLY ALONGSIDE MAKESHIFT DISPLAYS.**

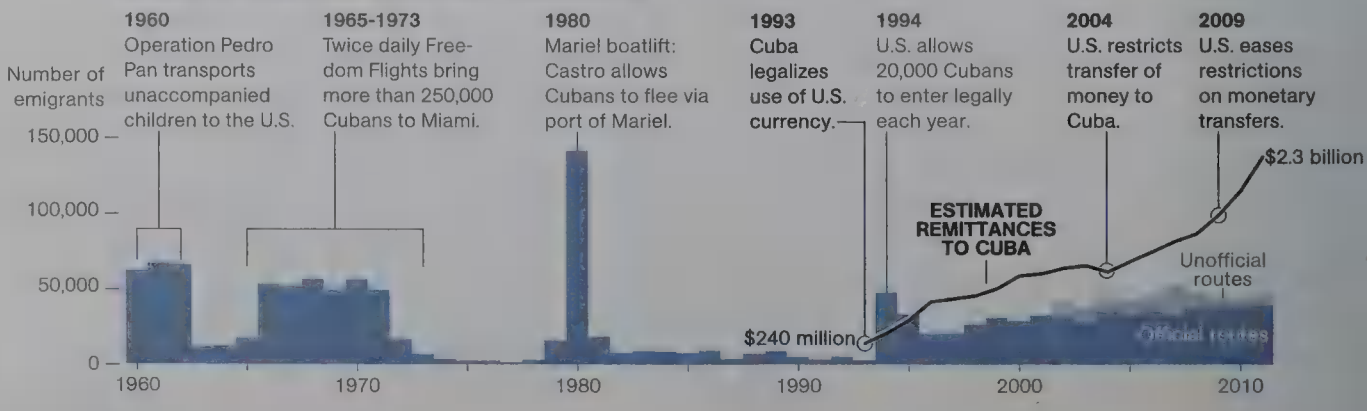
Most of the Cubans I talked to seemed consumed, in fact, by this whole idea of possibility. Not permanent transformation, most would say, not yet; the Cuban government has a history of switching signals on its citizens, encouraging private enterprise and then pronouncing it counterrevolutionary and shutting it down again. But Raúl Castro is not his brother, and there's a particularly Cuban combination of excitement, wariness, calculation, black humor, and anxiety that accompanies even the possibility of real change—the suggestion that after a half century under Fidel, something big may truly be happening to the way Cubans live day to day. "The rebuilding of the house of Cuba," an ecclesiastical lawyer and editor named Roberto Veiga said gravely, pronouncing the Spanish words with *(Continued on page 48)*

## CUBANS OUT, DOLLARS IN

Among the most reliable sources of hard currency are the billions in remittances flowing in from the Cuban diaspora and the more than two billion dollars spent annually by tourists. The number of people leaving the island each year fluctuates with the twists and turns of politics and policy.

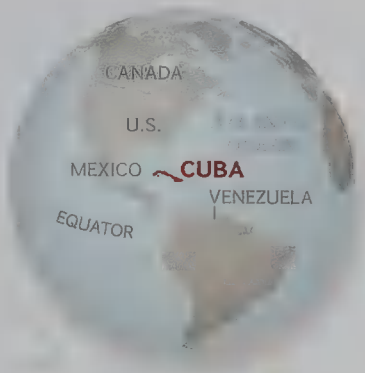
Cuban native and NGS cartographer Juan Valdés narrates an emigration time line.

### Postrevolutionary emigration and remittances



# CAN CUBA STAY AFLOAT?

Hampered by the U.S. embargo and the collapse of the U.S.S.R. in 1991, Cuba's economy has floundered. Today it is precariously propped up by Venezuelan aid. Production of sugar—and most agricultural and industrial products—has plummeted since the 1959 revolution. Its best hope for growth: oil, nickel—and people. Tourism is up, along with cash sent to residents from abroad.

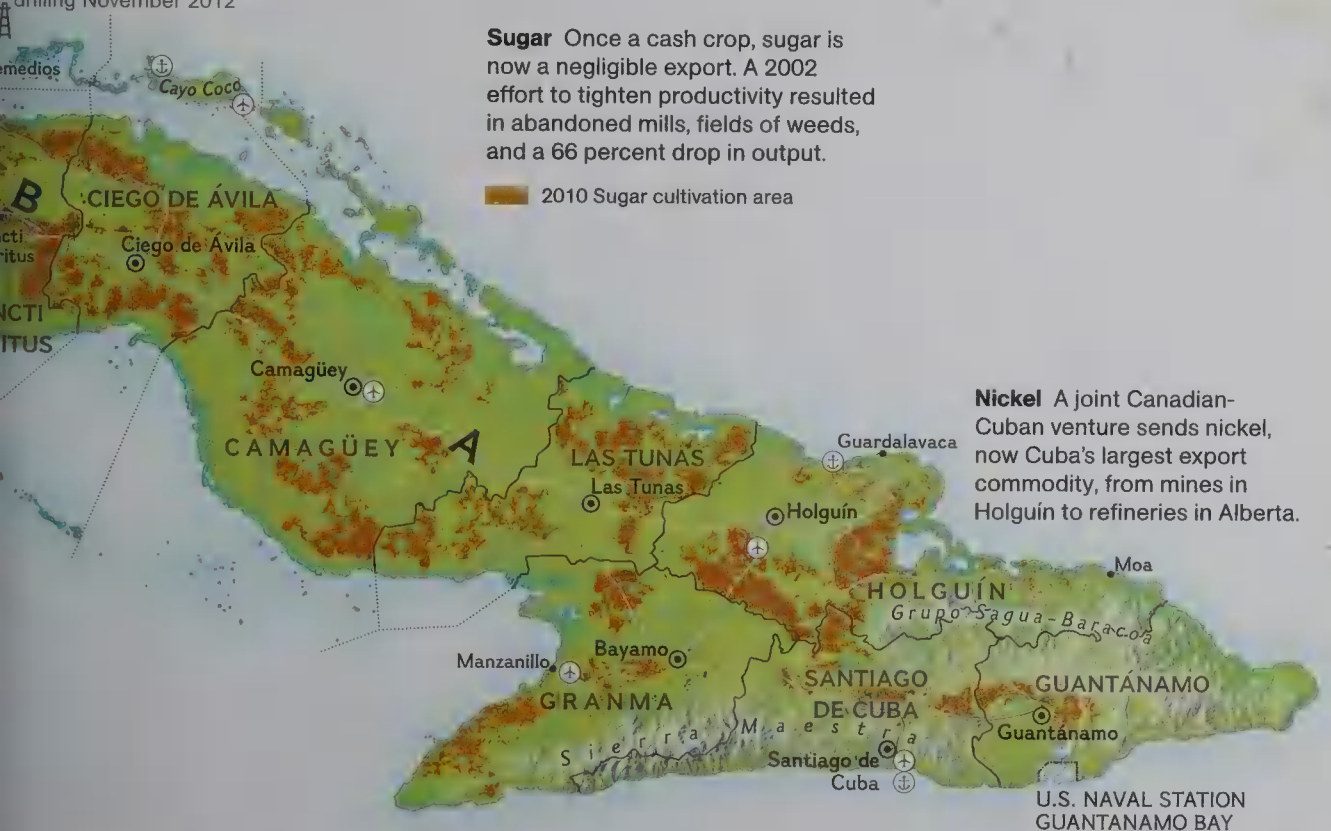



ZARUBEZHNEFT (Russia): drilling November 2012

**Sugar** Once a cash crop, sugar is now a negligible export. A 2002 effort to tighten productivity resulted in abandoned mills, fields of weeds, and a 66 percent drop in output.

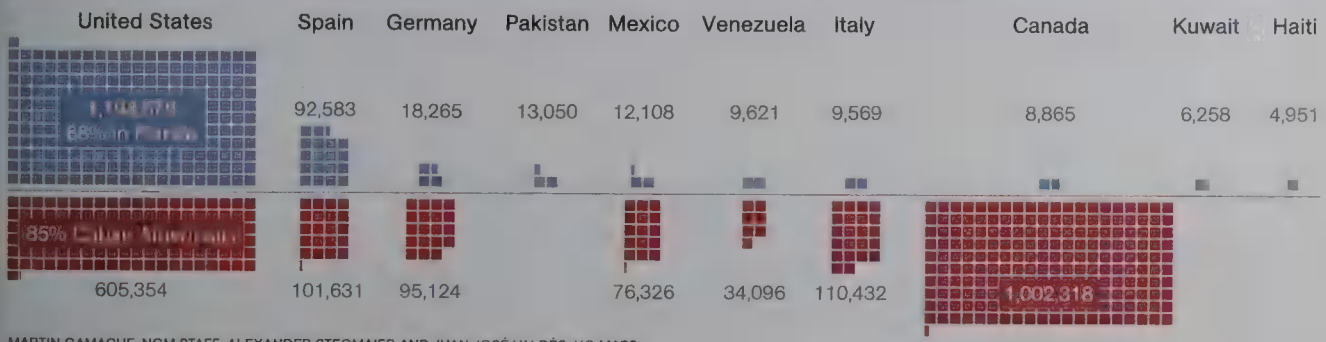
2010 Sugar cultivation area

**Nickel** A joint Canadian-Cuban venture sends nickel, now Cuba's largest export commodity, from mines in Holguín to refineries in Alberta.




## Cuban nationals abroad and tourists by country of origin

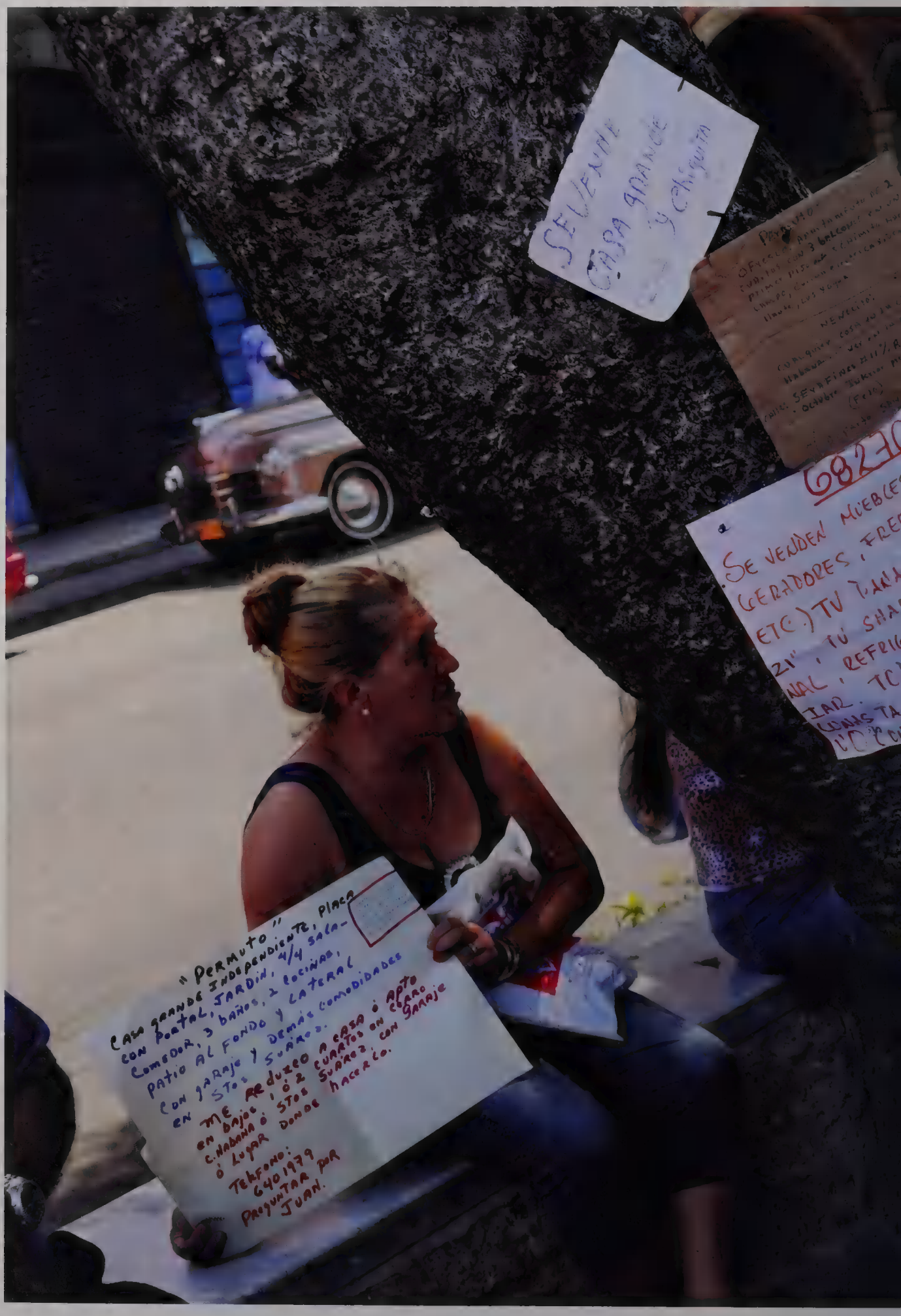
■ = 5,000 emigrants (total for most recent data available, 2007-2011) ■ = 5,000 tourists (2011 figures)




MARTIN GAMACHE, NGM STAFF; ALEXANDER STEGMAIER AND JUAN JOSÉ VALDÉS, NG MAPS

SOURCES: CUBAN NATIONAL STATISTICS OFFICE; FAO; U.S. CENSUS; U.S. CUSTOMS AND BORDER PROTECTION; UN STATISTICS DIVISION; DEVELOPMENT RESEARCH CENTRE ON MIGRATION, GLOBALISATION AND POVERTY; MIGRATION POLICY INSTITUTE; EMILIO MORALES AND JOE SCARPACI, HAVANA CONSULTING GROUP; ARCH RITTER, CARLETON UNIVERSITY; JORGE R. PIÑON, UNIVERSITY OF TEXAS AT AUSTIN; MODIS LAND COVER, NASA LP DAAC

*Movies, music, and TV shows are popular merchandise for Cuba's burgeoning private entrepreneurs. Discreet customer queries can sometimes unearth DVDs too racy—or politically inflammatory—for display.*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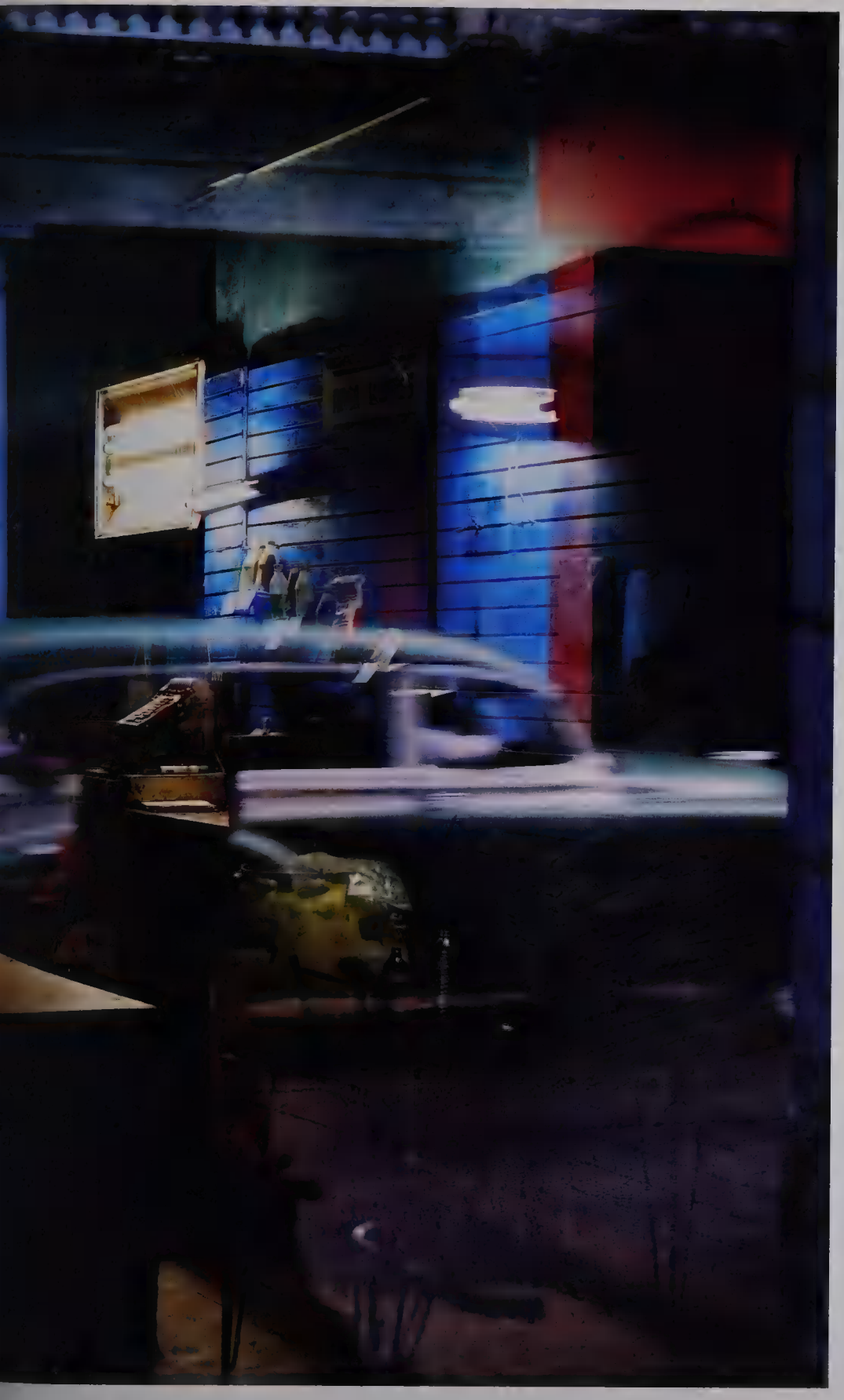
COMEDOR, 3 BAÑOS, 2 COCINAS,
PATIO AL FONDO Y LA TERRAZ
CON GARAJE Y DEMÁS COMODIDADES
EN STOS SUAREZ.
ME REDUZCO A CASA Ó APTO
EN BAJOS Ó 1 Ó 2 CUARTOS EN CÉNTRICO
C. HABANA Ó STOS SUAREZ CON GARAJE
Ó LUGAR DONDE HACER LO.
TELFONO:
6401979
PREGUNTAR POR
JUAN.

*For the first time in decades Cubans are allowed to buy and sell houses and apartments. Makeshift ads, fluttering from tree trunks, have turned Havana's Parque del Prado into an open-air real estate bazaar.*

CARNICERIA



*Hunting down groceries in poorly stocked markets, like this butcher shop in central Havana, is a daily challenge. Cubans receive ration books that secure staples like rice, beans, and oil at low prices. But it's not enough to live on.*

*Shoppers wait in line at a central Havana market. Poor management and decades of a U.S. embargo have crippled Cuba's agriculture. The country imports most of its food.*

*(Continued from page 39)* the elegance of a pastor at the pulpit: *La reconstrucción de la casa Cuba.*

Careful, though: The rebuilding metaphor implies a blueprint. Those outside Cuba who imagine that this blueprint is agreed to by some clear Cuban consensus are deluding themselves. The unconstrained individualism of the United States, where neither health care nor a college education are free? The showy wealth and environmental havoc of modern China? The economic woes and internal tensions of Europe? The narco wars of Mexico? "This is our great challenge," Veiga told me. He helps run a publication of the Archdiocese of Havana, *Espacio Laical* (literally, *Secular Space*), which, like the Cuban Roman Catholic Church itself, has become one of the few venues in which semicritical debate about the country's future is aired in public. "What will it be like, this house of Cuba?" Veiga asked. "These are changes that should have begun two decades ago. But they didn't. And now we are a nation trying to define itself."

Eleven million people live in Cuba, less than the population of central Tokyo. It's the biggest island in the Caribbean, and famously only 90 miles from United States territory, but Cuba still grips the international imagination mostly because the dueling narratives of its history are so exaggerated by myth. Either a ruthless revolutionary took power in 1959, seized American corporate property, forced out his country's own professional classes, and silenced all opposition by creating a totalitarian police state (that's the version audible to this day on Miami's Radio Mambí, the broadcast voice of Florida's most vehement anti-Castro community); or a brilliant revolutionary led the overthrow of a corrupt dictatorship, shook off the colonialism of foreign companies and the Mafia, brought literacy and health care and egalitarian values to a mobilized people, and created a university-educated bastion of socialism in spite of a half century of U.S. efforts to destroy it by prohibiting Americans from doing business with or spending tourist money in Cuba.

Both narratives contain substantial truth, both at the same time. This is why Cuba fascinates and makes people's heads hurt. The place is exhausting in its complexity and paradoxes—Cubans are the first to tell you that—and the questions modern Cuba sets off in a visitor

*In a government office in Viñales a receptionist labors under a portrait of retired leader Fidel Castro and a sign proclaiming that work must be orderly, disciplined, and demanding.*

are big, serious, unwieldy. What is the definition of freedom? What do human beings need? What do they owe to each other? What do they want, beyond what they need? "We've all been the subjects of an experiment," a 58-year-old university-educated woman who works in the arts told me thoughtfully one evening, chopping sweet peppers in her kitchen for supper. She lives in an airy place, with a fenced front lawn and a backyard patio, in a leafy part of Havana; the home has belonged to her family since before the Triunfo, the Triumph of the Revolution, as Cubans generally refer to the events of 1959. Her lightbulbs are compact fluorescents, the woman pointed out—one legacy of an ambitious national project a few years back, directing all Cubans to switch to lower watt fixtures in the interests of energy independence and the environment.

"They'd come to check," she said. "They would break your old bulbs, in front of you, to make sure you didn't sneak any back into your lamps." She smiled and looked over her glasses at me to make sure I was listening closely enough. She has one child, a son a decade younger than Eduardo—gone now, having bailed out on Cuba and obtained a therapy credential in Spain. "The idea was marvelous, to change all the lightbulbs," she said. "The problem is how they did it."

IN ITS HEADLINE VERSION, the rebuilding of the house of Cuba looks like this: Capitalism intrudes, around the edges, small bits at a time. Since 2010 more than 150,000 Cuban workers have left or been laid off from their state jobs, a concept previously unimaginable in a system that was supposed to provide all the work and all the social benefits. President Castro himself has said that the state apparatus is bloated and too conducive to dependence and corruption, and that the state must trim a half million workers. State agricultural land is now being leased in pieces to private farmers and cooperatives, and other kinds of legal self-employment are being gingerly promoted as well. Over the past two years the government has authorized 181 job-specific categories of *cuentapropismo,* as it's called—the keeping of one's own account.

Even the ration book—the *libreta* issued to all Cuban households, with its check-off columns for the state-subsidized basic foods every citizen

is supposed to get each month—may be an artifact near the end of its time, Raúl Castro has said. The libreta! This is big. Nothing is more evocative of the bewildering Cuban economy, and Cubans' complicated reaction to it, than the baseball card-size libreta, each one stapled together from thin cardboard and white paper and listing the items the holder may buy at artificially low prices: rice, sugar, and milk, if the family includes children under eight. There are squares to be checked off by hand. The pages look like the accounting ledgers of Dickensian clerks.

Here are things I have watched Cubans do with the libreta:

Reinforce its fraying cover carefully with decorative paper and tape.

Hold it in one hand, a plastic shopping bag in the other, while sweating in the moist heat, gossiping with neighbors, waiting for subsidized bread.

Whip it from their purses or off kitchen shelves, shoving the opened pages at me, exclaiming simultaneously that it demonstrates Cubans' care for each other and that the allotments have been so cut back the government might as well be trying to starve them all.

Once I was in the home of a priest of Santería, the Afro-Cuban religious practice that is the faith even of many professed Cuban Catholics. I was still trying to compose myself because the priest had just completed an initiation ceremony that included slitting the necks of pigeons and chickens and bleeding their corpses into sacred dishes and praying in Yoruba. But what the priest really wanted to talk about was his libreta. "Look at this!" he cried. "Eight ounces of oil, per person, for a month! Ten ounces of beans! One package of pasta maybe every three months!"

There's a term Cuban housewives use as they make their rounds in search of the day's family food: *pollo por pescado.* It means "chicken for fish": You have promised fish for dinner, but in the stores there is no fish, so you get a little chicken and pretend it's your fish. Cuba is surrounded by seawater, of course. Where is all the fish? Ah, any Cuban will tell you, leaning in close, a merry gleam in his eye: glad you asked, *mi amor.* The fish is in the restaurants. The fish is in the hotel buffets, a popular amenity for tourists, where long counters are piled high with varieties and quantities of food no ordinary Cuban ever sees. The fish is being sold out of private homes, if you know which doorbell to ring.

In many of these locales the fish—like nearly every desirable product in Cuba, from nightclub admission to hair dye and plasma TVs and acid-washed blue jeans—is being sold in CUCs.

Now we come to that aspect of present-day Cuba that causes the *yuma* (that's the grammatically adaptable slang for "American," "foreigner," and also "the general outside world to the north and east") to reach for a calculator and some aspirin and a crash course in recent Cuban history. The CUC, which is shorthand for Cuban convertible peso, is one of the two official currencies of Cuba. Like the libreta, the double-currency system is in theory destined for extinction; things are so fluid in Cuba that by the time you read this, it's conceivable the government will have begun ending it. But to appreciate fully the elaborate survival negotiations that have dominated so many Cubans' daily lives in recent years, you have to come to grips with the essential weirdness of the CUC.

It's a recently invented currency, introduced a decade ago as a replacement for the dollars and other foreign money that began flooding and disrupting the country after the Soviet Union collapsed in 1991, thus ending the big-socialists-to-little-socialists financial support that had been holding up the Cuban economy. The multiyear Cuban depression that followed the Soviet breakup was catastrophic (fuel shortages, 14-hour blackouts, widespread hunger), and the government set out to counter it by throwing the island open to international tourism. This was all done rather fiercely, with a flurry of beach hotel building that continues to this day—current plans include multiple golf courses and jet-capacity airports—while anti-capitalist admonishments still declaim from highway billboards and urban walls:

SOCIALISM OR DEATH!

THE CHANGES MEAN *MORE* SOCIALISM!

In its purest concept the CUC is used for goods and services somehow connected to foreignness: hotel bills, international transactions, Fidel T-shirts in the souvenir shops, and so on. One CUC is worth about one U.S. dollar, and it's simple to obtain them; whether you're a yuma or a Cuban, state employees at exchange centers will take whatever currency you hand them and count out your reciprocal CUCs, wishing you a pleasant day when they're done.

These employees, like the rest of the Cubans who work for the state—currently about 80 percent of the country's labor force—are not paid in CUCs. They're paid in the other currency, the Cuban national peso. One national peso is worth 1/24 of a CUC, or just over four cents, and in socialist Cuba state salaries are fixed; the range as of mid-2012 was between about 250 and 900 pesos a month. Some workers now receive a CUC stimulus to augment their peso wages, and recent changes are lifting top-end salary limits and linking pay more to productivity than to preset increments. But it was Cubans who taught me the national comic line about public workplace philosophy: "They pretend to pay us, while we pretend to work."

**ABOUT 80 PERCENT OF CUBA'S LABOR FORCE WORKS FOR THE STATE. THE WORKPLACE PHILOSOPHY THIS INSPIRES: "THEY PRETEND TO PAY US, WHILE WE PRETEND TO WORK."**

IN THE CITY OF SANTA CLARA, where the principal attraction is a massive monument to revolutionary martyr Ernesto "Che" Guevara (fought with Fidel, died trying to foment insurrection in Bolivia), I spent an afternoon with a visiting emergency physician whose medical salary was fixed at 785.35 national pesos per month. That works out to CUC$32.72. Like so much about Cuba, this isn't straightforward; Dr. M owes nothing for his professional education and his own family's medical care. His son's lifetime schooling is free. Produce and certain other basic foods not on the family libreta can be purchased in pesos, as can Cuban books, baseball game tickets, fares on the crowded public buses, and admission to museums and movie theaters and the ballet. The currency in which he is paid as a doctor will buy Dr. M the very kind of 1960s ascetic nationalism Che Guevara liked to espouse—in other words, as long as Señora M uses only the poor-quality peso soap, the M family brews only the peso coffee that comes with fillers ground in, and nobody ever buys deodorant.

"The toy truck I wanted for my son, with the little motor and remote control?" Dr. M said, as we stood side by side beneath the gigantic monument pedestal, craning our necks up at Che. "Forty CUCs."

Forty CUCs in a state store, that is. Cubans maintain a robust black market—*por la izquierda,* they call it, "over to the left"—in which anything can be obtained. But the most surrealistic aspect of life in Cuba 2012 is the vigor with which the government, the same entity paying Cubans in pesos, sells goods to Cubans in CUCs. Retail stores, like pharmaceutical factories and nickel mines, are national enterprises, run by the state. Clerks often don't bother specifying "CUC" on the pricing of merchandise either; if a thing whirs or glitters or comes in good packaging, Cubans know the currency in which it is being sold, and regardless of whatever the ghost of Che may be whispering in their ear, they want it.

By the time I met Dr. M, I had done so much confounded window-shopping that there were numbers all over my notebooks: Pepsodent toothpaste, CUC$1.50 per tube. Electric blender, CUC$113.60. Upholstered loveseat-and-armchair living room set, CUC$597.35.

*A plume of fireworks surrounds a reveler at the Parrandas, a December festival in the colonial town of Remedios, near Cuba's north coast. Two barrios compete to stage the most impressive display.*

*Until the 1959 ouster of dictator Fulgencio Batista, Cuba's legislature convened in the domed Capitolio building in Havana. Today it's a symbol of a prerevolutionary Cuba that no one under the age of 50 experienced.*

Multistory malls, with cafés and video game halls and clothing stores, all functioning exclusively in CUCs.

The cell phones Cubans depend upon—pre-Raúl they were prohibited; now they're everywhere—are sold, both the device and the per-minute fees, in CUCs. Even a Bucanero Fuerte, one of the good Cuban beers, is likely to be sold in CUCs. The Bucanero price of one CUC, not an unreasonable sum in many countries for a bottle of beer, constitutes a full day's medical pay for Dr. M. You see the problem with the toy truck. This is why for four days a week, when he's supposed to be recuperating from his 24-hour emergency shifts, Dr. M drives a cab.

Technically, he drives his own car, the aged Russian beater he inherited from his father. But he picks up tourists in it, because tourists pay in CUCs. Over one high-season month Dr. M's cabbie days earn him the CUC equivalent of 15 times his salary as a physician. In Cuba there's nothing remarkable about this. The taxi fleet, like the rest of the tourist industry, is replete with splendidly educated Cubans no longer practicing their professions because their years of study to be of service to the nation—in engineering, medicine, psychology—produced salaries in "the money that's worthless," as a kindly Cuban bank teller once remarked to me. The phenomenon is referred to as the "inverted pyramid." Every Cuban who repeated that term to me did so in a tone of despair, as in: This, you see, is why the ambitious young keep leaving.

Dr. M and I studied the object Che was holding in his giant fist above us, determined that it was a hand grenade, and went into the museum. Che Guevara was an Argentine medical school graduate when he met Fidel Castro, and as we walked past the glass-encased displays of the Che medical journals and the Che lab coat, I glanced over at Dr. M. In the 15 years since Che's ashes were delivered to Santa Clara, Dr. M told me, this was the first time he had visited the museum. But he was silent and impassive, and when we came out, all he said was, "I don't get this about us now—how a taxi driver can make so much more than a doctor." The expression on his face made it clear that Che Guevara was not a topic he wished to continue exploring. "I don't get it," he said.

EDUARDO TOLD ME the boat's departure date was set, depending on what the men could learn about tide and weather predictions, for the days just after the pope's visit ended. When I was away from Havana, in the island's interior, text messages from his number showed up every so often on my temporary Cuban phone: "hi my friend am going soon on vacation."

I was doing a lot of walking, or strapping on flimsy passenger helmets and climbing (imprudently) onto the backs of unlicensed motorcycle taxis. To my outsider's eye, the New Changing Cuba looked both real and raggedy, as though an enormous flea market had been busted up and scattered the length of the country. Young men sat in stairwells, offering to repair cell phones or refill cigarette lighters. Families lined their front porches with display tables of used kitchen merchandise or thermoses of coffee and chipped plates of wrapped ham-and-cheese sandwiches.

Here were small corner businesses that used to be run by the state but now, experimentally, were not: barbershops and snack bars, for example, in which management was being transferred to the employees. Here was a former high school math teacher, a soft-spoken 42-year-old who had learned to speak Russian fluently back in the comfortable days of life support from the U.S.S.R. Now he was selling baby clothes for CUCs from one corner of a rented street-front foyer in the central city of Camagüey. "My wife does the sewing," the former math teacher said. "She used to be a teacher too."

And here, in the middle of one residential block back in Havana, was a chic new restaurant called Le Chansonnier. No signage marked the entrance; Le Chansonnier is a *paladar,* a privately run restaurant inside a home, and people with money—correction, people with CUCs—know where it is. Paladares have been legal for years in Cuba but used to be strictly contained, under the pretense that they were all tiny family operations siphoning no business from state

restaurants. Since 2011, though, they've been allowed to expand and hire staff, and like the guest rooms Cubans may rent to foreigners inside their own homes and apartments, some of the popular paladares have basically turned into busy CUC cash registers for their owners. "I always dreamed of having my own business," the co-owner, a 39-year-old named Héctor Higuera Martínez, told me the afternoon I stopped by. "I used to think I'd be an engineer. But I saw that there was a living in working with tourists."

Higuera waved a hand at somebody and in short order produced an amazing salad for me, with beautiful butter lettuce, shaved chicken, and a dusting of chocolate. He was trying to figure out how to manage the evening's multiple parties of ten; dinner at Le Chansonnier, which draws foreigners and Cubans alike, runs about 40 CUCs per person. His business partner, Laura Fernández Córdoba, who's run the restaurant with him since they opened in fall 2011 with the help of French investors, was approving a tableware purchase in the next room. It was easy to envision money flying in and out of the building, in a New Changing Cuba sort of way, and part of what had been flummoxing me during my early weeks in Cuba was starting to come clear. Not every Cuban drives a taxi or tends bar for tourist tips, right? So how on Earth, I had wondered every time I examined all the nonpeso merchandise being hawked at Cubans from every direction, were they accumulating these CUCs?

Part of the answer is remittances, the dollars and euros sent from relatives abroad. The amount of money sent to Cuba annually is hard to track, but some economists estimate the number may surpass $2 billion this year. That means the modern Cuban state is being nourished partly by people who've left it. And because both the U.S. and Cuban governments have eased restrictions on émigrés returning to visit family, the Cuban Americans who arrive to weepy reunion embraces at the Havana airport are usually carrying both money and goods: televisions, appliances, duffel bags full of clothing, and anything else their relatives can resell por la izquierda for CUCs.

There's stealing too, which during the post-Soviet-collapse depression years emerged as a nationwide mechanism for family survival. The verb *luchar,* which means "fight," also translates loosely in Cuba to "transfer workplace items into one's personal possession, which the system impels us to do because our salaries won't cover a lousy Bucanero." The standard lucha involves eating, drinking, using, bartering, or selling the items in question. Reform campaigns pushed by Raúl Castro have produced scores of high-level corruption arrests, but one defining quality of any attractive workplace, still, is the nature of the lucha. ("If you can't look around and find things you can take home or resell," a woman in her 40s from a working-class neighborhood outside Havana told me firmly, "then it's not a good job.")

**MANY CUBANS NO LONGER PRACTICE THEIR PROFESSIONS BECAUSE YEARS OF STUDY—IN ENGINEERING, MEDICINE—PRODUCED SALARIES IN A CURRENCY THAT'S WORTHLESS.**

Nothing about this combination, remittances plus pilfering, is unusual in a small tropical country without abundant raw material for export. Neither is the third important way CUCs arrive in Cubans' pockets: legal commerce, of any sort, that directly or indirectly procures foreigners' money. But the government of the Cuban *proyecto socialista,* or socialist project—in official dispatches that remains the preferred term—has tried for a half century to wall off much of the country from the very buy-sell system that generated that money in the first place. Watching Cubans grapple, as they consider just how many of those walls ought now

to be dismantled, is a sobering experience. Take Higuera and Fernández: Their private, for-profit business and their ten employees are legal under the new self-employment laws, as long as they pay their taxes.

But business taxes, in themselves a relatively new concept in Cuba, increase sharply as employers hire more people. The system is weighted against much private expansion while Cubans experiment with new tax and regulation policies, and this question of limits—of just how successful individual entrepreneurs should aspire to become—is a matter of great philosophical and political contention in the New Changing Cuba. Last year, after months of discussions around the country, a remarkable official document called "Guidelines for the Economic and Social Policy of the Party and the Revolution" was published—313 guidelines, to be exact, each one addressing a specific subject, like land use or the civic importance of sports. Guideline number three declares that the "concentration of property" by individuals, as opposed to the state, "will not be permitted."

What does that mean, exactly? The guidelines don't say. The cynical will tell you it means the government shall countenance no threat, no real business competition, to the bureaucracies and personal fiefdoms of government companies. The less cynical will tell you that it means Cuba must manage this move toward privatization carefully, while trying to protect the services Cubans have come to expect—that there remains some genuine national conviction in Cuba, no matter how exhausted the SOCIALISM OR DEATH! slogans may now appear to the young, that it's deeply wrong for certain citizens of a nation to make themselves thousands of times wealthier than others.

"We just don't know yet," a veteran University of Havana economist named Juan Triana Cordoví told me, when I asked about guideline number three. "You can do this big bang style, as Russia did, but I don't think that worked very well. Or you can do it step-by-step, watching what will happen. I am one of the ones who prefer step-by-step. I think of it as testing the stones of the river, one foot at a time, to see if each stone will hold."

I could see how the guidelines, which were released to great fanfare, might look from a certain perspective like one more saltshaker only a quarter full. This is why so many young people spend a lot of time talking to their peers about their futures in Cuba, about whether to stay or go. There are multiple routes away now, most much safer than little boats pushed out to sea in the dark. Family members wait out the long delays for visas to join relatives abroad. Professionals overseas on Cuban service missions, like the thousands of medical professionals and sports trainers now working in Venezuela, sometimes decline to return home. "You're always trying to convince people not to leave," Higuera said. "Always. I have a friend in Madrid now. He got there just in time for the crash."

**WHAT MIGHT THEY SAY, I WONDERED, IF THEY COULD TALK DIRECTLY TO A CUBAN I KNEW BUYING CANNED TUNA THIS VERY WEEK FOR AN ILLEGAL DEPARTURE INTO THE STRAITS OF FLORIDA?**

What might he and Fernández say, I wondered, if they could talk directly to a Cuban I knew, halfway between their two ages, buying canned tuna this very week for an illegal departure into the Straits of Florida?

Higuera sighed. "I'd say to him, If you're going to do this thing, do it," he said.

I had heard this before, after asking other Cubans the same question, and it still surprised me a little; I expected to hear the word *gusano,* worm, which in an earlier era was the famous public castigation for anybody who abandoned

*Cockfighting is a long-standing tradition that survived the revolution and thrives in rural settings. This young Cuban cradles a contestant in the province of Pinar del Río.*

the revolution. But I never did. People would nod and say they understood. Or they'd point to a framed picture—on a wall, hanging from a rearview mirror—of a relative who'd already done the same thing. "But I'd tell him to make sure he's doing it for himself, not somebody else's expectation of him," Higuera said. "And I'd ask him to look hard at what he sees in other places. I really do have hope that things are improving here."

A week later I went home, and I waited for Eduardo to call me collect, as we'd both arranged, from somewhere in South Florida. Two weeks passed without a call. Then another week, and then another. I tried the Havana cell phone Eduardo had been using, but there was no answer, and finally I called his brother, who immigrated to Mexico a few years ago to marry a Mexican woman he had met in Cuba.

The phone connection was bad, and I wasn't sure how much was safe to say. I was an American who had befriended Eduardo in Havana, I said, and I just wondered—how he was, that was all. I said he had spoken of an impending vacation. His brother became very excited. "He didn't make it," he said in Spanish. He was shouting into the phone. "There was a problem with the boat. *El timón.* They didn't make it."

I didn't have my dictionary in reach, and I didn't know what a timón was, and all I could think was that it was like *tiburón,* which means shark. *"Tell me what that means,"* I said urgently, and Eduardo's brother said he didn't know how to describe it exactly but that it was a boat part, a thing that had failed before they were too far out, and it was all right, they had used the oars, they were back in Cuba. No one was arrested. He was going to wait a while, Eduardo's brother said, and stay in their mother's apartment with his wife while he saved some more money.

After we hung up I got the dictionary. A timón is a rudder. I had a picture in my mind now, what had happened to Eduardo: Floating in the sea, the rudder broken, he and his companions had surely discussed it for a time, what would happen if they tried to motor on, toward a landfall they couldn't see, with nothing beneath them to keep the direction true. Then they turned the boat around, back into the piece of the ocean they already knew, and rowed home. □

# ESCAPE

Preparing to launch from the sea to the sea ice, an emperor penguin reaches maximum speed.

# VELOCITY

Awkward on land, emperor penguins soar through the sea. Now scientists have discovered the secret of their speed.

Photographs by Paul Nicklen

An airborne penguin shows why it has
a need for speed: To get out of the water,
it may have to clear several feet of ice.
A fast exit also helps it elude leopard seals,
which often lurk at the ice edge.

ROGER HUGHES has never seen emperor penguins in the wild. But when he saw them in a BBC documentary, rocketing through the sea with trails of bubbles in their wakes, he had an insight that would lead to a surprising discovery. A marine biologist at Bangor University in north Wales, Hughes had recently been talking with his wife about the lubricating properties of new competitive swimsuits. He wondered: Maybe those bubbles help penguins swim faster.

Over beer in a pub, Hughes bounced his hypothesis off his friend John Davenport, a marine biologist at University College Cork in Ireland. "Roger thought I'd have the answer straightaway," says Davenport, who studies the relationship between animals' body structures and their movements. But he didn't know what the bubbles did for the penguins. It turns out no one else knew either. The two men combed the scientific literature and found that the phenomenon had never even been studied. So they decided to do it themselves.

With the help of Poul Larsen, a mechanical engineer at the Technical University of Denmark, they analyzed hours of underwater footage and discovered that the penguins were doing something that engineers had long tried to do with boats and torpedoes: They were using air as a lubricant to cut drag and increase speed.

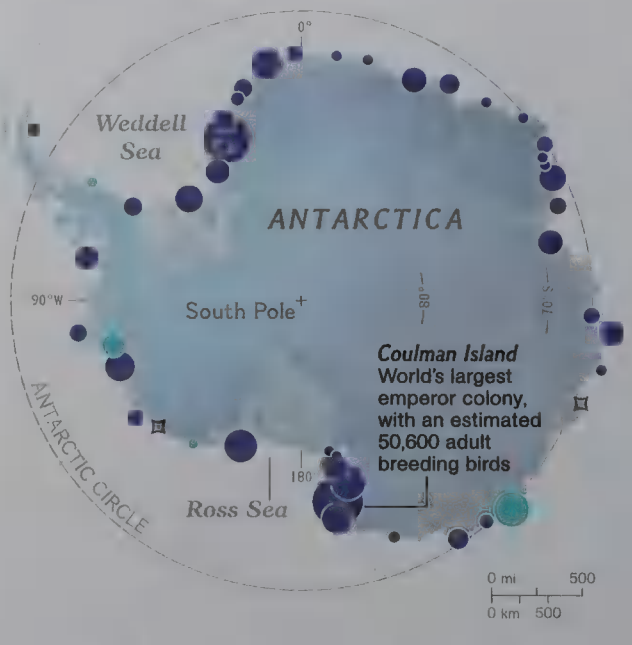
When an emperor penguin swims through the water, it is slowed by the friction between its body and the water, keeping its maximum speed somewhere between four and nine feet a second. But in short bursts the penguin can double or even triple its speed by releasing air from its feathers in the form of tiny bubbles. These reduce the density and viscosity of the water around the penguin's body, cutting drag and enabling the bird to reach speeds that would otherwise be impossible. (As an added benefit, the extra speed helps the penguins avoid predators such as leopard seals.)

The key to this talent is in the penguin's feathers. Like other birds, emperors have the capacity to fluff their feathers and insulate their bodies with a layer of air. But whereas most birds have rows of feathers with bare skin between them, emperor penguins have a dense, uniform coat of feathers. And because the bases of their feathers include tiny filaments—just 20 microns in diameter, less than half the width of a thin human hair—air is trapped in a fine, downy mesh and released as microbubbles so tiny that they form a lubricating coat on the feather surface.

Though feathers are not an option for ships, technology may finally be catching up with biology. In 2010 a Dutch company started selling systems that lubricate the hulls of containerships with bubbles. Last year Mitsubishi announced that it had designed an air-lubrication system for supertankers. But so far no one has designed anything that can gun past a leopard seal and launch over a wall of sea ice. That's still proprietary technology. *—Glenn Hodges*

**Seeing Penguins From Space**

Recent analysis of satellite imagery identified four new colonies and nearly doubled the total estimated population of emperor penguins.




**Emperor penguin colony**
(46 identified, as of 2009)

- Discovered in 2009
- No current population estimate

**Estimated colony population**
(Global total: 595,000*)

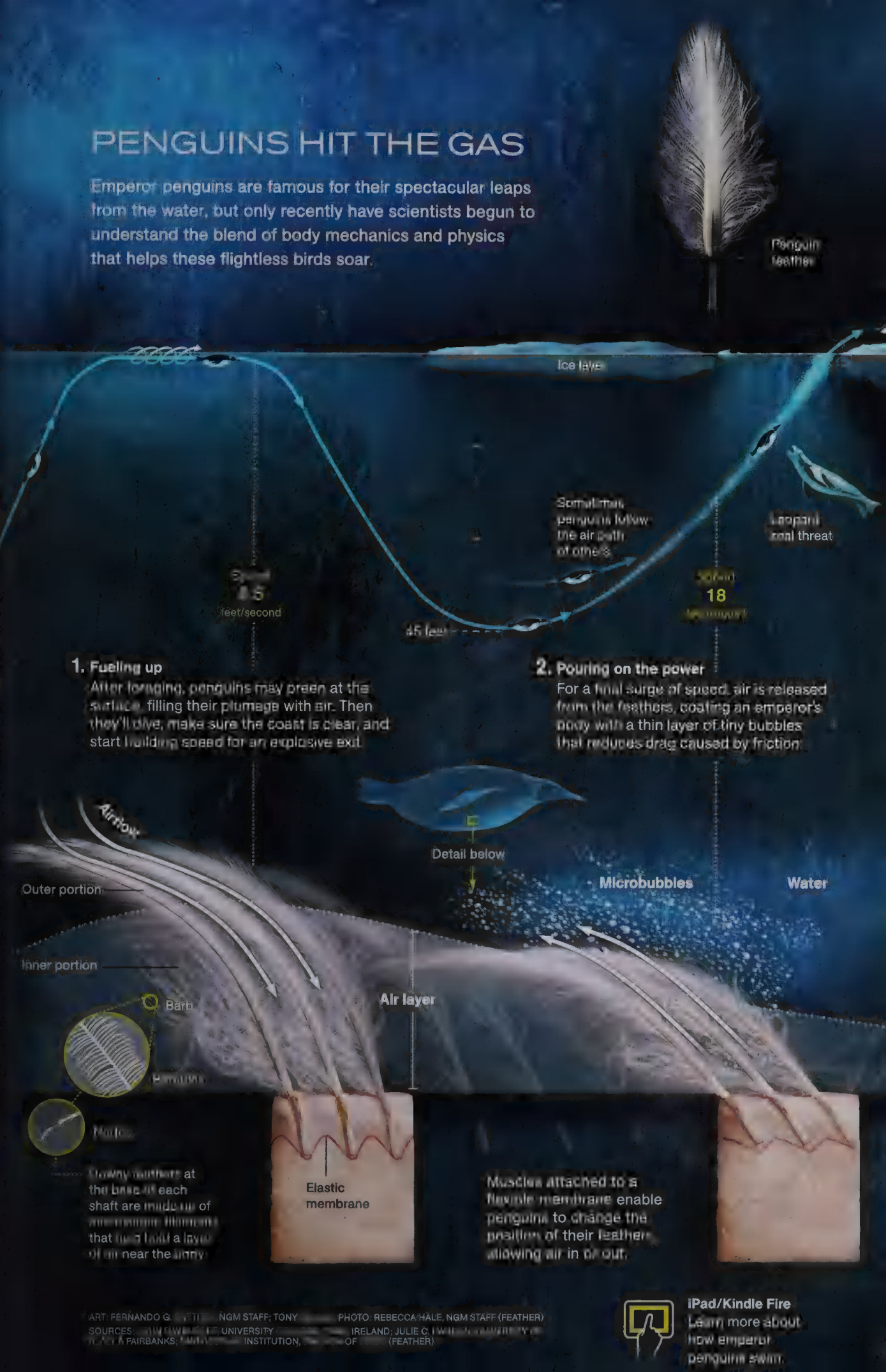
- 50,000 adult breeding birds
- 20,000
- <3,000

*Includes nonbreeding adults

MAGGIE SMITH, NGM STAFF. SOURCES: BRITISH ANTARCTIC SURVEY; POLAR GEOSPATIAL CENTER, UNIVERSITY OF MINNESOTA

# PENGUINS HIT THE GAS

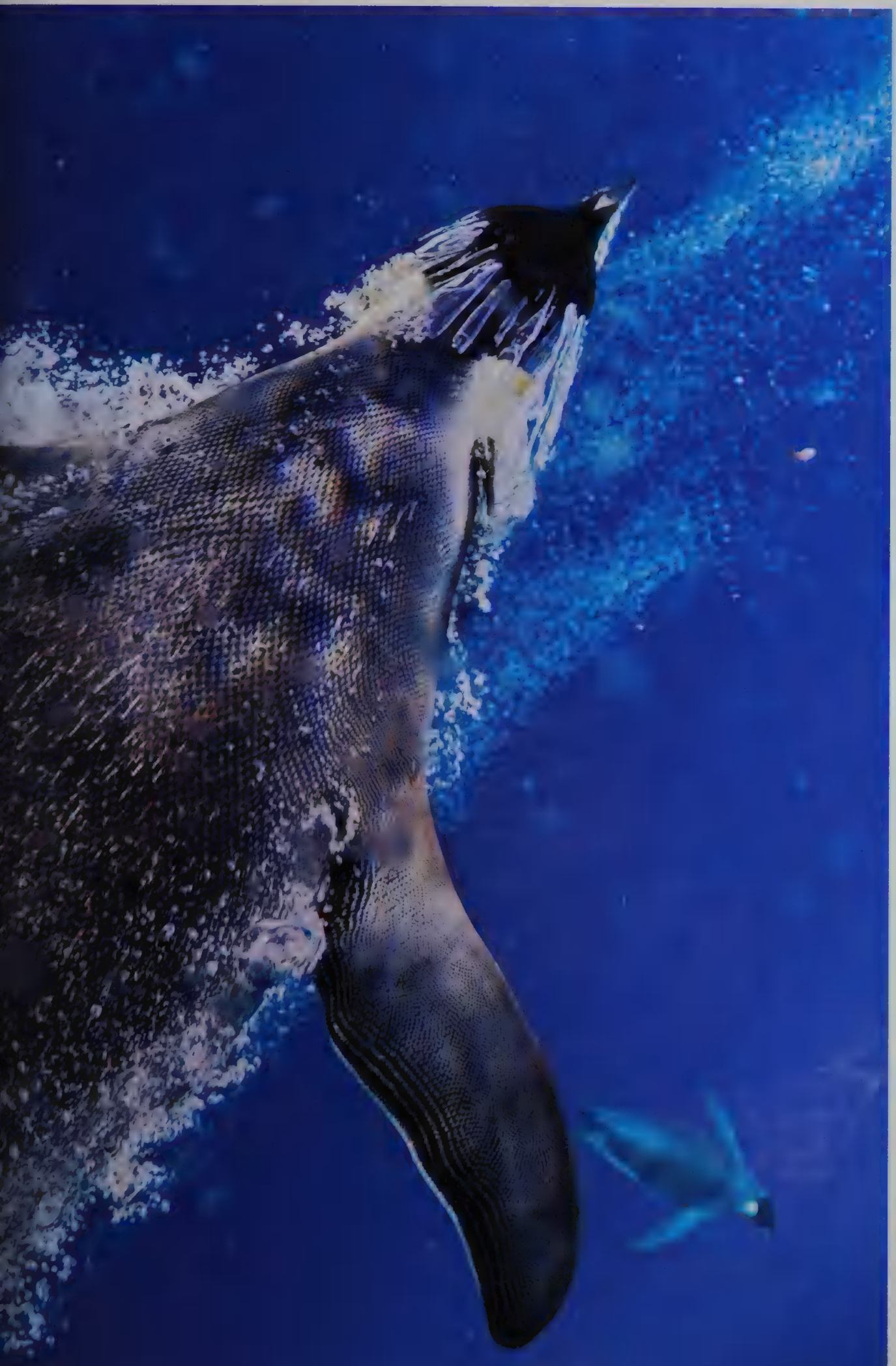
Emperor penguins are famous for their spectacular leaps from the water, but only recently have scientists begun to understand the blend of body mechanics and physics that helps these flightless birds soar.


Penguin feather
Ice layer
Sometimes penguins follow the air path of others
Leopard seal threat
Speed
5
feet/second
45 feet
18
1. Fueling up
After foraging, penguins may preen at the surface, filling their plumage with air. Then they'll dive, make sure the coast is clear, and start building speed for an explosive exit.
2. Pouring on the power
For a final surge of speed, air is released from the feathers, coating an emperor's body with a thin layer of tiny bubbles that reduces drag caused by friction.
Airflow
Detail below
Microbubbles
Water
Outer portion
Inner portion
Barb
Air layer
Elastic membrane
Muscles attached to a flexible membrane enable penguins to change the position of their feathers, allowing air in or out.

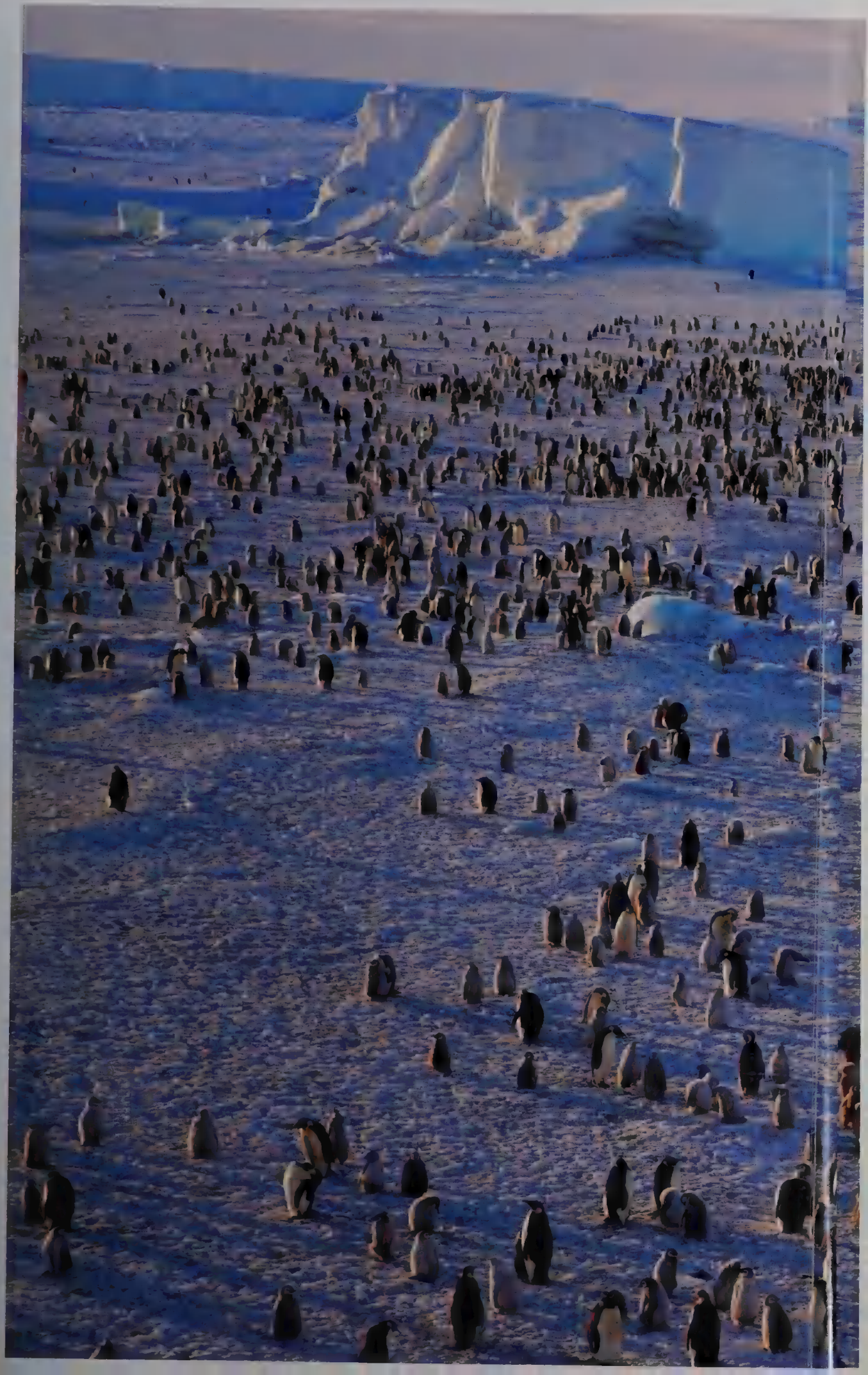
ART: FERNANDO G. [illegible] NGM STAFF; TONY [illegible] PHOTO: REBECCA HALE, NGM STAFF (FEATHER)
SOURCES: [illegible] UNIVERSITY [illegible] IRELAND; JULIE C. [illegible] OF FAIRBANKS; [illegible] INSTITUTION; [illegible] OF [illegible] (FEATHER)

**iPad/Kindle Fire**
Learn more about how emperor penguins swim.

An emperor's dense feathers—about a hundred per square inch that overlap like roof tiles—seal out water and trap air in a downy underlayer. When released, the air coats the bird in lubricating bubbles.



After hunting at sea to get food for their chicks, adult penguins swim at the surface, which loads their plumage with air. Then they'll dive deep, gather speed, and race toward their exit hole.



At a colony on the frozen Ross Sea, emperor parents and chicks bask in the brief summer sun. The distance to open water varies with the season; in midwinter birds may have to cross many miles of ice to feed.

The danger of ambush by leopard seals is greatest when entering the water, so penguins sometimes linger at the edge of an ice hole for hours, waiting for one bold bird to plunge in. Life is safer at the colony (left), where predators are few and company is close.

Emperors can bolt away for any number of reasons, as photographer Paul Nicklen discovered when he spooked this group. "A tenth of a second after I took this picture, all I could see were bubbles."

Without the safety of numbers, a lone penguin corkscrews to get a 360-degree view of its surroundings. When it leaps from the water, it will land with a thump and a squeak and leave its most graceful moves behind.

# VIKINGS *and* NATIVE AMERICANS

## *face-to-face*

*Following a subtle trail of artifacts, a Canadian archaeologist searches for a lost chapter of New World history.*

BY HEATHER PRINGLE

PHOTOGRAPHS BY DAVID CONTENTY

new clues suggest that
this ancient American
who carved this face
mask may have dealt
with Viking explorers on
friendly terms.
ALL ARTIFACTS
MUSEUM
CANADIAN

Daring Viking seafarers used ships like this modern replica to reach the New World in their search for furs, walrus ivory, and trading partners—which they may have found in the native Dorset people.

VIKING SHIP MUSEUM, ROSKILDE, DENMARK

## SOMETHING ABOUT THE STRANGE STRANDS DIDN'T FIT.

Patricia Sutherland spotted it right away: the weird fuzziness of them, so soft to the touch.

The strands of cordage came from an abandoned settlement at the northern tip of Canada's Baffin Island, far above the Arctic Circle and north of Hudson Bay. There indigenous hunters had warmed themselves by seal-oil lamps some 700 years ago. In the 1980s a Roman Catholic missionary had also puzzled over the soft strands after digging hundreds of delicate objects from the same ruins. Made of short hairs plucked from the pelt of an arctic hare, the cordage bore little resemblance to the sinew that Arctic hunters twisted into string. How did it come to be here? The answer eluded the old priest, so he boxed up the strands with the rest of his finds and delivered them to the Canadian Museum of Civilization in Gatineau, Quebec.

Years passed. Then one day in 1999 Sutherland, an Arctic archaeologist at the museum, slipped the strands under a microscope and saw that someone had spun the short hairs into soft yarn. The prehistoric people of Baffin Island, however, were neither spinners nor weavers; they stitched their clothing from skins and furs. So where could this spun yarn have come from? Sutherland had an inkling. Years earlier, while helping to excavate a Viking farmhouse in Greenland, she had seen colleagues dig bits of similar yarn from the floor of a weaving room. She promptly got on the phone to an archaeologist in Denmark. Weeks later an expert on

Donny Pitseolak patrols for polar bears on the shores of Baffin Island, where archaeologists have discovered cordage made the Viking way (facing page) and other evidence of European contact.

Viking textiles informed her that the Canadian strands were dead ringers for yarn made by Norse women in Greenland. "That stopped me in my tracks," Sutherland recalls.

The discovery raised tantalizing questions that came to haunt Sutherland and drive more than a decade of dogged scientific sleuthing. Had a Norse party landed on the remote Baffin Island coast and made friendly contact with its native hunters? Did the yarn represent a key to a long lost chapter of New World history?

VIKING SEAFARERS were the explorers par excellence of medieval Europe. Crafting sturdy wooden sailing ships that inspire awe even today, they set sail from their Scandinavian homeland hungering for land, gold, and treasure. Some voyaged west to what is now Scotland, England, and Ireland in the eighth century, bringing death by the sword in raids immortalized in medieval manuscripts. Many turned to foreign commerce. As early as the ninth century Viking merchants nudged eastward along the shores of the White and Black Seas and navigated the shoals of eastern European rivers. They founded cities on major Eurasian trade routes and bartered for the finest wares from the Old World—glassware from the Rhine Valley, silver from the Middle East, shells from the Red Sea, silk from China.

The most adventurous set their courses far west, into the treacherous fogbound waters of the North Atlantic. In Iceland and Greenland,

Viking colonists carved out farming settlements and filled storehouses with Arctic luxuries destined for European markets, from walrus ivory to spiraling narwhal tusks that were sold as unicorn horns. Some chieftains, fearless in the face of the unknown, pressed farther west, navigating through iceberg-strewn waters to the Americas.

Sometime between A.D. 989 and 1020, Viking seafarers—perhaps as many as 90 men and women in all—landed on a Newfoundland shore and raised three sturdy halls and an assortment of sod huts for weaving, ironworking, and ship repair. In the 1960s a Norwegian adventurer, Helge Ingstad, and his archaeologist wife, Anne Stine Ingstad, discovered and excavated the overgrown ruins of this ancient base camp at a place called L'Anse aux Meadows. Later, Canadian archaeologists found iron ship rivets and other artifacts from what appeared to be a Viking shipwreck off the coast of Ellesmere Island. But in the years that followed, few other traces of the Vikings' legendary exploration of the New World came to light—that is, until Patricia Sutherland came along.

IN THE SOFT MORNING LIGHT on Baffin Island, Sutherland and her field crew wind single file down a rocky footpath into a green hollow known as Tanfield Valley. The high wind of the previous evening has died, and the heavy clouds have cleared, leaving blue sky along the rugged coast that Viking seafarers once called Helluland—"stone slab land." Long before the Vikings arrived, the area's ancient inhabitants built a settlement here, at a site known today as Nanook.

As Sutherland clambers down the hill, she scans the shoreline warily for polar bears. The coast is clear this morning, and as she crosses between two freshwater ponds, she marvels aloud at the valley's thick, spongy moss. "It's full of greenery, full of turf for making buildings," she says. "It's the greenest valley in the area."

Sutherland, now a research fellow at the University of Aberdeen, smiles at the perfection of it all. Below us lies a protected cove, a natural harbor for an oceangoing Viking ship.

*Few other traces of the Vikings' legendary exploration of the New World came to light—that is, until Patricia Sutherland came along.*

Unearthing what she believes to be a Viking outpost, archaeologist Patricia Sutherland (in orange jacket) and her colleagues work in Baffin Island's Tanfield Valley, which offered turf for sod shelters and a harbor for ships.

## CONTACT POINTS

The earliest known Viking settlement in the New World was discovered in 1960 at L'Anse aux Meadows. Now new evidence of Viking traders is turning up farther north, at sites once occupied by native people known as the Dorset.

Along some boggy patches in the valley, an oily-looking microbial slick suggests the presence of bog iron, the ore that Viking smiths worked expertly. But as Sutherland scrambles up a small rise to the excavation, her high spirits evaporate. Eight inches of muddy water from the previous night's storm flood the pits. Draining them will require hours of bucket brigades and pumping. "We're running out of time here," she snaps.

With her silver-gray curls, girlish voice, and diminutive five-foot-nothing frame, Sutherland seems an unlikely expedition leader. But the 63-year-old archaeologist is a rolling storm in camp. She is the first up each morning and the last to crawl into a sleeping bag at night. In between she seems to be everywhere—flipping pancakes, making lunches for Inuit elders, checking the camp's electric bear fence. She makes nearly every decision, whether large or small. Just three months earlier she underwent major shoulder surgery; after four weeks of excavation her left arm is so swollen that she tucks it into a sling.

But Sutherland is nothing if not determined. In 1999 the discovery of the yarn sent her back to the storage rooms at the Canadian Museum of Civilization. She began scrutinizing artifacts that other archaeologists had dug from sites of Arctic hunters known today as the Dorset, who ranged the eastern Arctic coast for nearly 2,000 years until their mysterious disappearance in the late 14th century. Poring over hundreds of presumably Dorset artifacts, often under a microscope, Sutherland discovered more pieces of spun yarn that had come from four major sites—Nunguvik, Tanfield Valley, Willows Island, and the Avayalik Islands—scattered along a thousand miles of coastline, from northern Baffin Island to

*Sutherland found several carvings of what looked to be European faces, with long noses and prominent eyebrows.*

northern Labrador. Sutherland also noticed something decidedly odd about the collections from these sites. Teams working there had turned up numerous pieces of wood, despite the fact that the landscape is treeless tundra. To Sutherland's astonishment, she discovered fragments of what seemed to be tally sticks, used by Vikings for recording trade transactions, and spindles, which might have been for spinning fibers. She also noted scraps of wood with square nail holes and possibly iron stains. One was radiocarbon-dated to the 14th century, toward the end of the Norse era in Greenland.

The more Sutherland sifted through the old Dorset collections, the more evidence she found that Vikings had come to these shores. While examining the stone tools, she discovered nearly 30 traditional Norse whetstones, standard gear for Viking men and women. She also found several Dorset carvings of what looked to be European faces, with long noses, prominent eyebrows, and possibly beards.

All these artifacts pointed strongly to friendly contact between Dorset hunters and Viking seafarers. But to gather more clues, Sutherland needed to excavate, and Tanfield Valley seemed the most promising of the four sites. In the 1960s American archaeologist Moreau Maxwell had dug part of a peculiar stone-and-turf structure there. The ruins, he later wrote, were "very difficult to interpret," but he finally concluded that wandering Dorset hunters had built some sort of house there. Sitting in her office, surrounded by trays of Viking artifacts, Sutherland found that hard to believe. The Dorset had built snug homes the size of an average modern bedroom. The house in Tanfield Valley, one wall of which measured more than 40 feet long, would have been much, much larger.

Did Vikings use these notched sticks to record trade transactions? Patricia Sutherland thinks so.

ON A COLD ARCTIC AFTERNOON Sutherland hunches over a square of earth inside the mysterious stone ruins. With the tip of her trowel she loosens a small piece of whale bone. Lifting the piece free, she brushes away the dirt, revealing two drill holes. The Dorset had no drills—they made holes by gouging—but Viking carpenters stowed augers in their tool chests, and they often drilled holes for wooden dowels used to fasten pieces of wood together.

Sutherland slips the find into a plastic bag. Earlier archaeologists, she explains, excavated extensively in the ruins, so she and her colleagues must work like forensic investigators, searching for minute, overlooked clues that could shed light on Tanfield Valley's occupants. In sediments taken from inside the walls, for example, Sutherland spied several tiny pelt fragments. Expert analysis later revealed that they belonged to an Old World rat species, most probably the black rat, which must have reached the Arctic by ship.

The ruins have yielded other clues that aren't so subtle. One team member excavated a whalebone shovel closely matching those found in Greenland's Viking settlements. It's "the exact size and material as the spades used to cut sod for houses," notes Sutherland. And that makes a lot of sense. Sutherland and her colleagues found remnants of turf blocks—a material the Vikings used to build insulated walls—and a foundation made of large rocks that appear to have been cut and shaped by someone familiar with Norse stone masonry. The overall size of the

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*Vancouver-based Heather Pringle writes about archaeology for a variety of publications. David Coventry last photographed Panama's golden chiefs.*

Skillfully working walrus ivory, Dorset artists portrayed the mysteries and wonders of their remote Arctic world, from wandering polar bears (below) to what may be the face of a European visitor (above). Carvings on a piece of antler (facing page) present a study in contrasts. One face is broad and round, features typical of the indigenous Dorset. The other is long and narrow with a prominent nose and heavy brows, evoking a European.

Lacking bows and arrows and living in small bands, Dorset hunters, like the one shown in this carving, likely posed little threat to the Vikings. Eventually (and mysteriously) the Dorset disappeared.

structure, the type of walls, and a drainage channel lined with stones resemble features of Viking buildings in Greenland. One area still has the telltale reek of a latrine. Along the floor, a team member excavated hand-size clumps of moss, the Viking equivalent of toilet paper. "The Dorset people were never in places long enough to build a toilet structure," says Sutherland.

But why would restless Vikings stop long enough to build on this blustery corner of Helluland? What treasures did they seek?

TOWARD THE END of the ninth century a wealthy Viking trader arrived at the court of King Alfred the Great in England. An effusive man dressed in rich, foreign attire, Ohthere told of a long voyage he had taken to the coast of the White Sea, where northerners known as the Sami had furnished him with rare Arctic luxuries, from otter and marten furs to bushels of soft bird down. Then the Viking trader presented the king with walrus ivory that could be carved into gleaming chess pieces and other exquisite works of art.

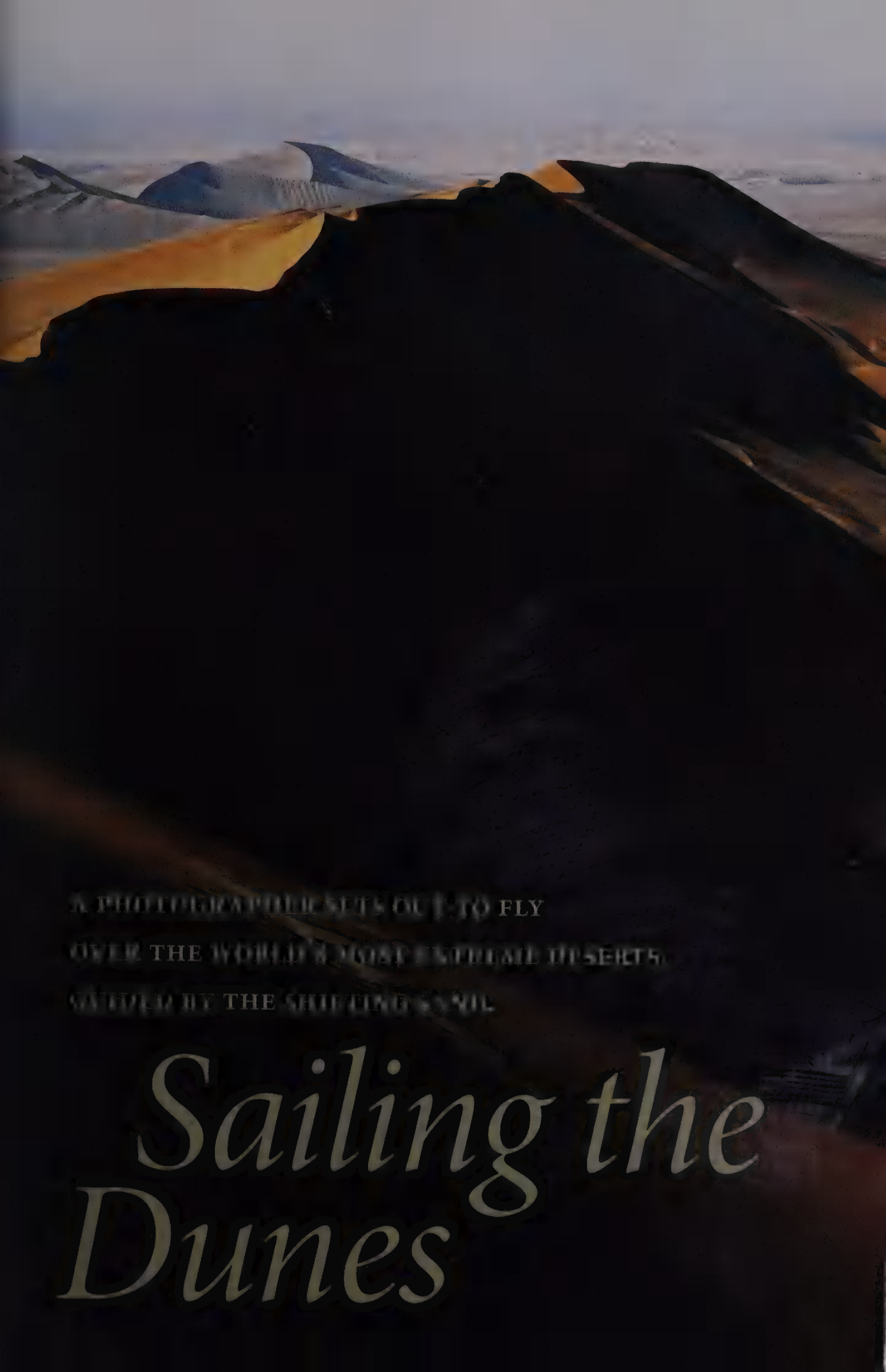
Ohthere was not the only Viking merchant who catered to the European appetite for fine goods from the frozen north. Each spring, men from Greenland's Western and Eastern Settlements went north to a rich coastal hunting ground known as Nordsetur. Camping along the shore, these medieval Greenlanders pursued walrus and other Arctic game, filling their boats with skins, furs, ivory, and even live polar bear cubs for trade abroad. Just two or three days west of Nordsetur, across the choppy waters of the Davis Strait, lay another, potentially richer Arctic treasure-house: Helluland. Its glacier-topped mountains loomed forbiddingly, but its icy waters teemed with walruses and narwhals, and its lands abounded with caribou and small fur-bearing animals.

The Viking seafarers who explored the North American coast a thousand years ago likely searched, as Ohthere did, for trading partners. In Newfoundland, a region they called Vinland, the newcomers met with a hostile reception. The aboriginal people there were well armed and viewed the foreigners as intruders on their land. But in Helluland small nomadic bands of Dorset hunters may have spotted an opportunity and rolled out the welcome mat. They had few weapons for fighting, but they excelled at hunting walruses and at trapping fur-bearing animals, whose soft hair could be spun into luxurious yarn. Moreover, some researchers think the Dorset relished trade. For hundreds of years they had bartered avidly with their aboriginal neighbors for copper and other rare goods. "They may have been the real entrepreneurs of the Arctic," says Sutherland.

With little to fear from local inhabitants, Viking seafarers evidently constructed a seasonal camp in Tanfield Valley, perhaps for hunting as well as trading. The area abounded in arctic fox, and the foreigners would have had two highly desirable goods to offer Dorset hunters for their furs: spare pieces of wood that could be carved and small chunks of metal that could be sharpened into blades. Trade in furs and other luxuries seems to have flourished. Archaeological evidence suggests that some Dorset families may have prepared animal pelts while camping a short stroll away from the Viking outpost.

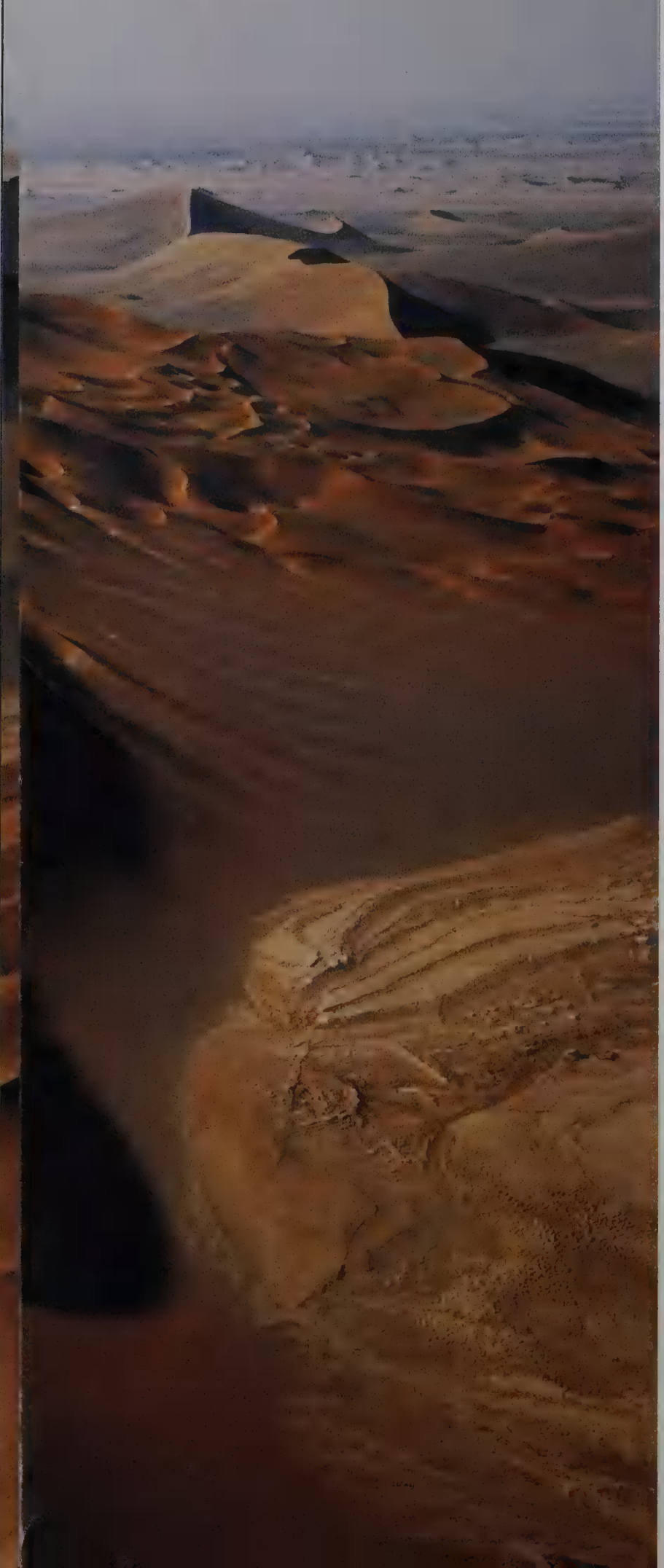
Thirteen years ago, when she first spotted the curious strands of cordage, Sutherland could never have envisioned a small Viking trading post standing on the coast of her beloved Arctic. But for Sutherland much work remains. Only a small fraction of Tanfield Valley has been investigated, and Sutherland's remarkable findings—new evidence of friendly contact between Viking seafarers and aboriginal North Americans, and the discovery of what is probably the earliest European fur trade in the Americas—have stirred intense controversy among many of her colleagues. Archaeology is all about interpreting the evidence. As with the discovery of L'Anse aux Meadows decades ago, the fight for acceptance will be hard and long. But Sutherland is determined to prove the doubters wrong.

She pulls the mosquito netting over her face and resumes digging. "I think there is more to dig here, absolutely," she says with a smile. "And we are going to find much more." □

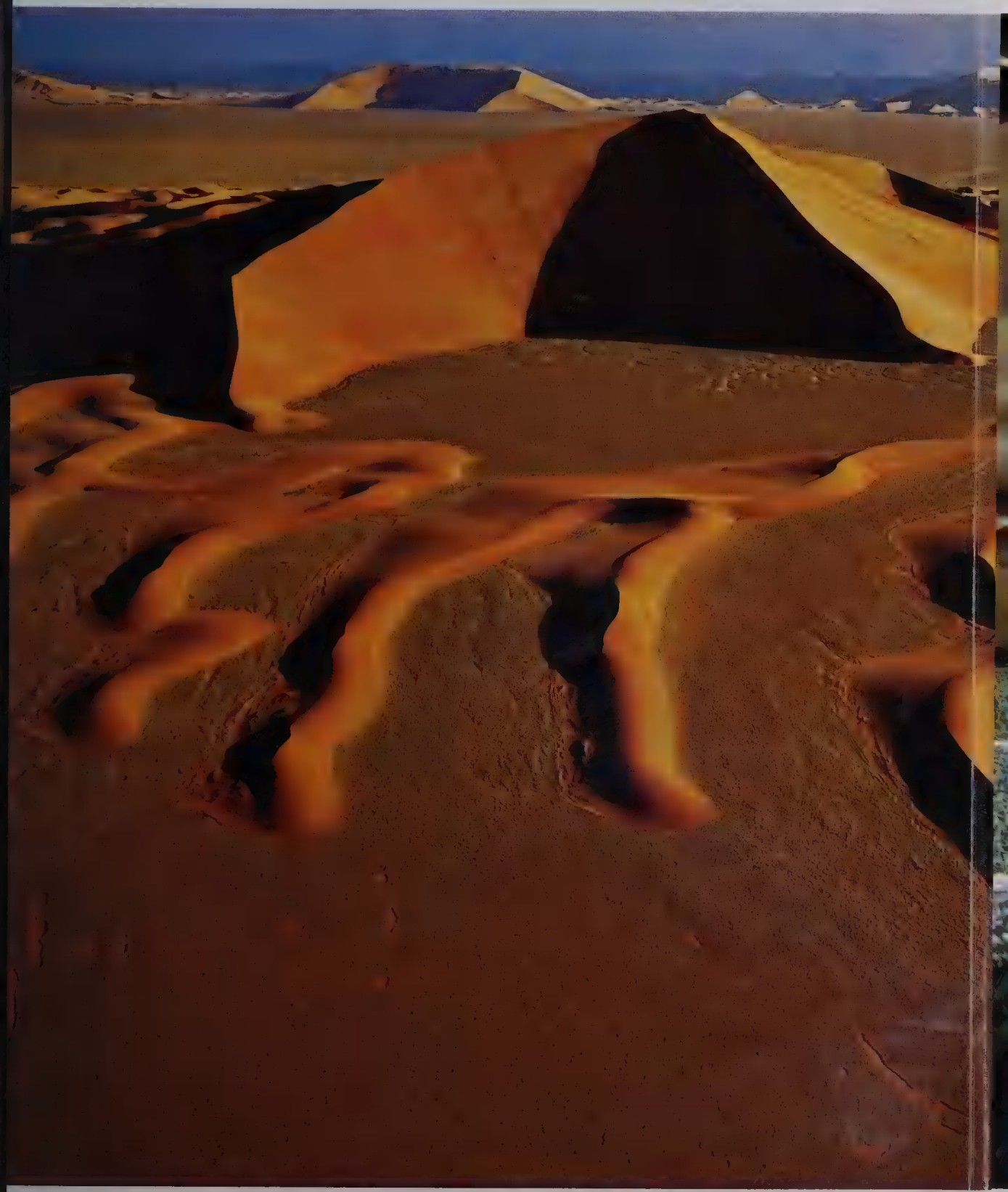


A PHOTOGRAPHER SETS OUT TO FLY
OVER THE WORLD'S MOST EXTREME DESERTS,
SAILED BY THE SHIFTING SAND.

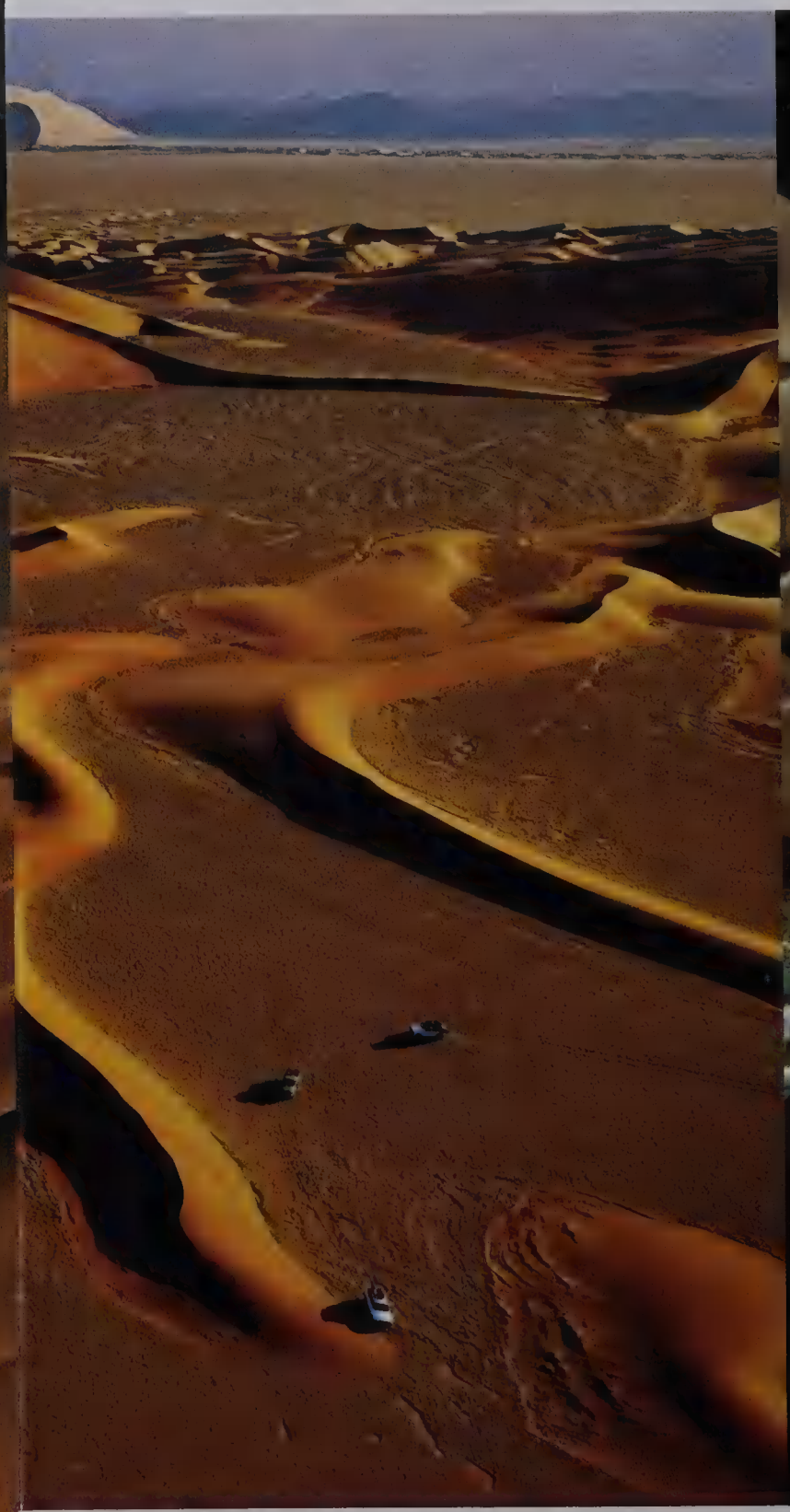
# *Sailing the Dunes*

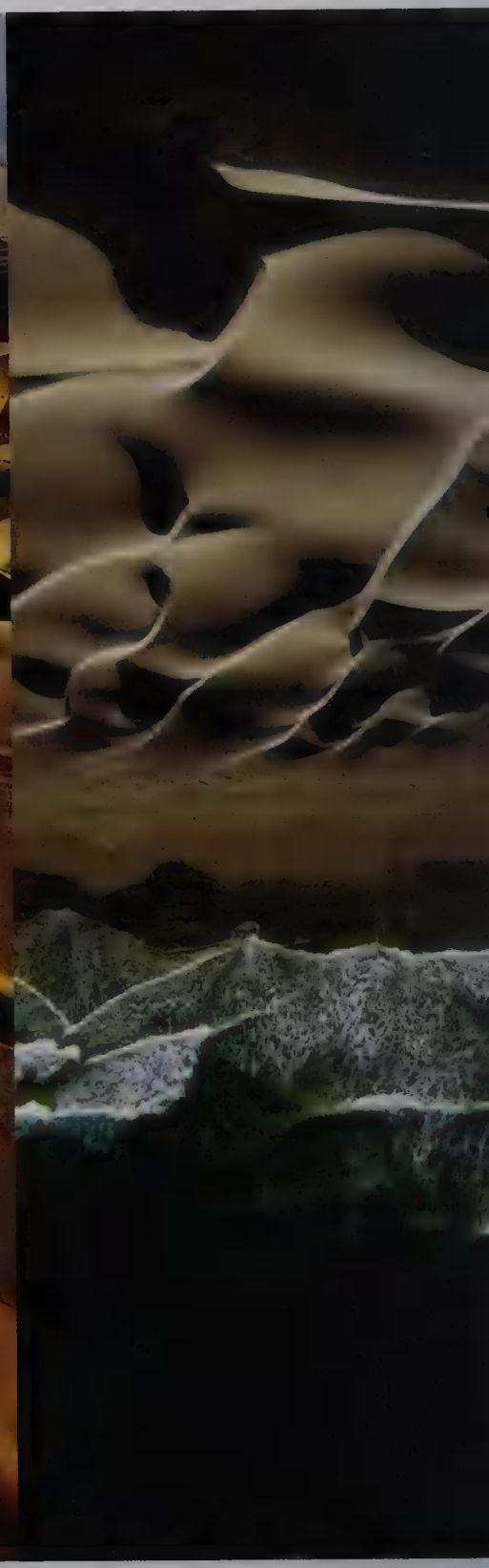


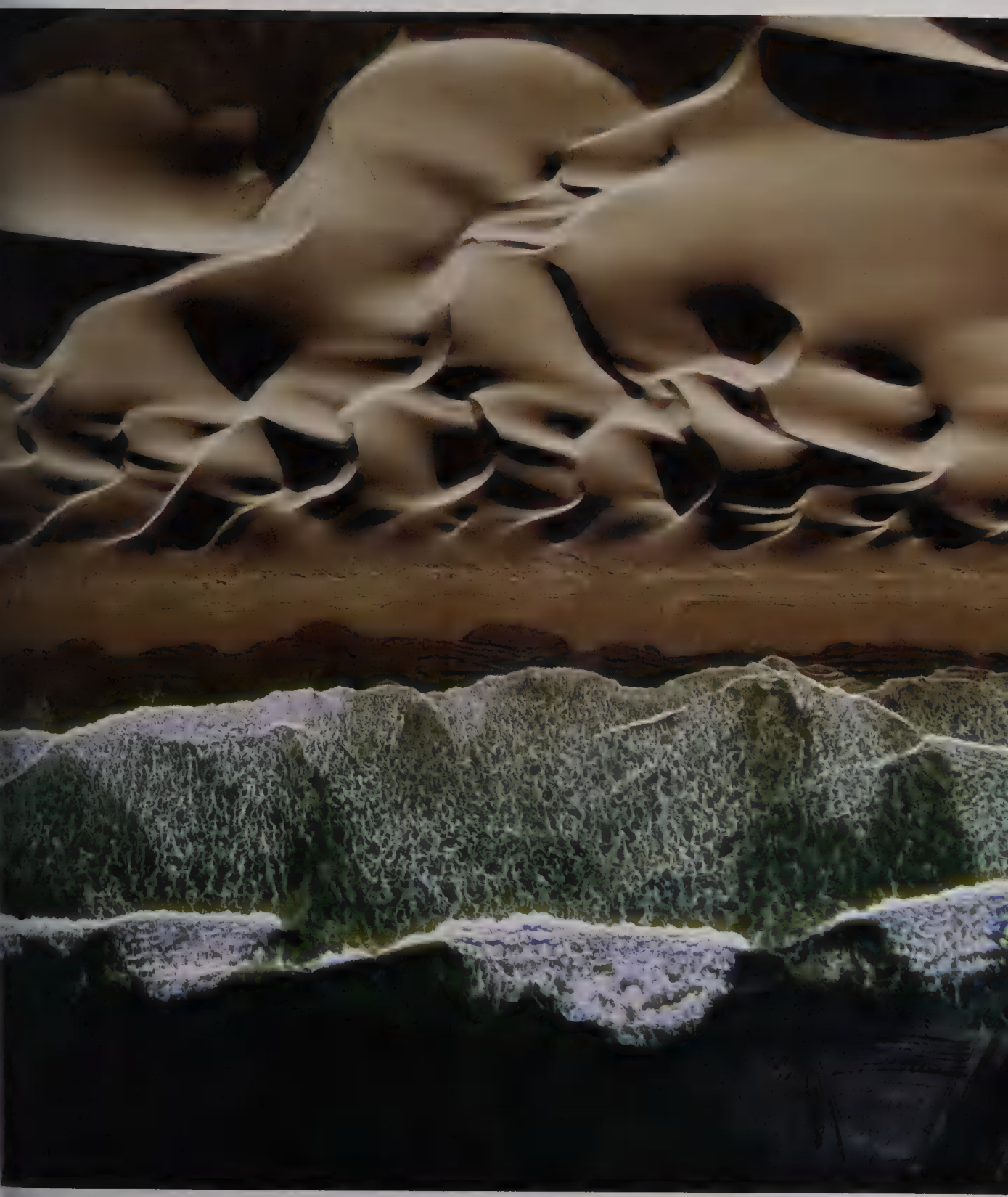
**DASHT-E LUT ▪ IRAN**
Aloft in a wilderness of blowing sand, Alain Arnoux pilots his motorized paraglider in tricky winds along a massive dune in Iran's vast Lut Desert. Frenchman Arnoux, a champion flier, has assisted photographer George Steinmetz on more than a dozen aerial expeditions to document the shape-shifting beauty of the world's arid zones.



**RUB AL KHALI ▪ SAUDI ARABIA** Young dunes flow like calligraphy in the Rub al Khali, Arabic for Empty Quarter. Towering above them, a star dune, because of its size, will likely hold its spot for decades.







**PACIFIC COAST ▪ PERU** Strong southerly winds fashion a chain of dunes on a remote beach in central Peru. Ocean waves supply huge amounts of the dune-building sand.

PHOTOGRAPHS AND TEXT BY
GEORGE STEINMETZ

I got my first lesson in the physics of sand dunes in 1998 on an expedition into the Sahara. In order to take aerial photos in this remote part

of the world, I had learned to fly a motorized paraglider, one of the lightest and slowest aircraft in the world. It weighs a little under a hundred pounds; its top airspeed is 30 miles an hour. And it has no wheels.

I mastered new skills to fly (and land) the paraglider. But there was one I hadn't realized I'd need to survive the Sahara: reading sand dunes. Just as the sailor watches whitecaps for the sudden squall, I had to learn to anticipate the invisible currents of air that created the dunes. If I wasn't paying attention, I could get caught in turbulence—or even a fatal downdraft.

The Sahara is traversed by endless rows of dunes called barchans. The word means "crescent-shaped dune" in the Turkic languages of eastern Europe and Central and northern Asia. I had become intrigued with them while reading a book by Ralph Bagnold, a British Army officer who pioneered motorized travel in the Libyan Desert in the 1920s and '30s. Bagnold described barchans as life-forms—they move, multiply, maintain structure, and adapt to their environment. I thought they might be interesting to photograph from above.

But first I had to reach the dunes. I traveled to the region with France's Alain Arnoux, a champion of motorized paragliding. I was counting on him to help me fly safely. Getting to the barchans took us four days in a four-wheel drive, traveling from N'Djamena, the capital of Chad, to the far north. The sand that makes up the dunes had traveled too, migrating west from Egypt and Sudan. We were guided by an

**BADAIN JARAN ▪ CHINA** Improbable jewel-bright lakes nestle among thousand-foot-high star dunes in a desert where Mongolian goat and sheep herders live. They depend on the springs that feed these salt lakes.

old French map that depicted the dunes as right parentheses, all pointing into the wind.

I did not realize the difficulties that awaited. Nor did I realize the allure of dunes. Once I started flying in the desert, I came under its spell and began what turned out to be a 15-year project to photograph the world's most extreme deserts.

When we got to the Mourdi Depression, my traveling companion had bad news. Shouting to be heard over the gale, Alain told me there was no way even he could fly in such wind. So we drove out into the middle of the broad stony basin until we found a 50-foot-tall barchan to give us some shelter for the night.

We awoke before dawn. The wind on the dune crest had died down to a breeze. I took off at sunrise, running down the windward slope of the dune. After gaining 500 feet, I felt like an insect flying over an enormous conveyor belt in a croissant factory. The barchans stretched to the horizon as they combined, separated, and spawned progeny.

I soon became nervous. The wind was much faster than I was, so I was being pushed backward while heading into it. It was like trying to swim up a river against a current that's moving faster than you can swim. That's a frightening experience for a pilot. You can't see what's behind you, and when you land, you have a hundred pounds on your back and a large sail over your head that wants to keep moving backward.

Ground friction slows the wind, especially in the morning, so I dropped to within 50 feet of the dune crests to advance. After an hour even the wind down low began to increase and become turbulent. The sun was heating up the dark ground, creating bubbles of rising hot air that broke up the smooth flow of wind across the surface. When I gained altitude to find our dune camp, I began flying with the wind instead of against it and suddenly found myself moving ahead at more than 70 miles an hour—an alarming speed. I turned into the wind and hovered like a kite 200 feet above camp. Alain came zooming in underneath me. Landing in such a gale made me anxious, and I watched to see what the champion would do.

He read the dune like an open book: The wind was rushing over the top of its crest and then doubling back. To try and land near our cars, parked in the dune's inner arc, would be fatal. The paraglider is an inflated wing; in turbulent air it could lose rigidity and crumple. Landing on the dune's windward slope was a better option, but a gust could push us back into the whirlpool of wind—and a nasty mess. As I watched, Alain made the prudent choice and landed in the gravel plains beside the dune, avoiding the turbulence. I soon came down to join him.

Alain had given me a great lesson in reading the winds. After 26 desert flying expeditions, I've had a lot of postgraduate training. I have found that dunes are both flyable and beautiful in the calm first hours of morning.

And I've learned to be patient and to pick my seasons carefully. In the Sahara, for example, fall is best because the winds are relatively light and the weather is cool.

I still fear sandstorms, which can come up with little notice. I've even learned how to land in them: as soon and as quickly as possible. With an aircraft that flies faster than I can run, I have also learned that dunes are my friends. They're soft and always point the direction to a safe landing. You don't need a weatherman to know which way the wind blows when you have dunes to inform you.

I have developed a few simple rules. The smallest dunes are the ones most affected by the wind, so their direction indicates the way the wind is blowing. If at all possible, land on the sunny side of a sand dune; the shady side usually has downdrafts, so you just drop like a stone. White sand is safer to fly over than dark sand. Dark sand absorbs the heat, then releases it in big bubbles of hot air, like a lava lamp. When the sand is blowing off the dune crests, it's a good time to be on the ground. And last, it's always better to be on the ground wishing you were in the sky than in the sky wishing you were on the ground. □

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*George Steinmetz is the author of the new book* Desert Air, *featuring photos of extreme deserts made while he soars in his "flying lawn chair."*

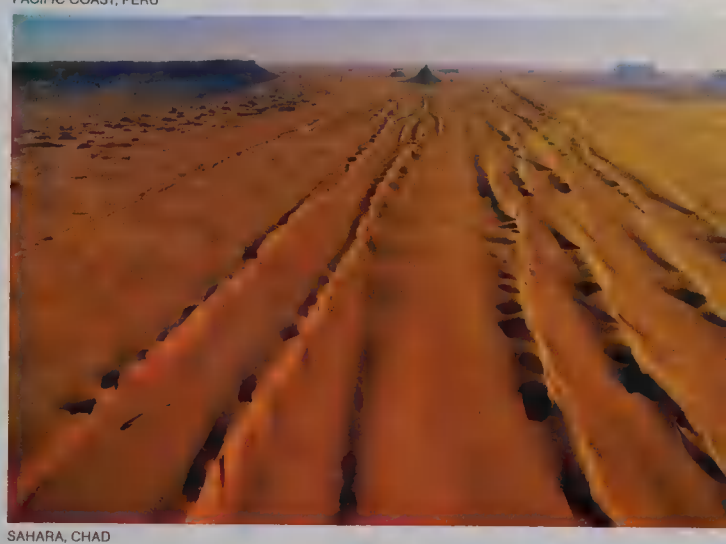
# Sand Dune Formation

Covering some 20 percent of the world's deserts, dunes form wherever there's constant wind and loose sand. Size depends on the supply of available sand; shapes follow the dictates of wind direction.

**Barchan**
"Barchan" is Turkic for a crescent-shaped dune—found on the edge of sand seas and formed when the wind blows steadily from one direction.

PACIFIC COAST, PERU

**Seif**
Elongated, sharp-crested seifs, named after the Arabic word for sword, take shape in regions with moderate sand and shifting winds.


SAHARA, CHAD

**Star Dune**
Seasonally changing winds create multiarmed, pyramid-shaped dunes. Building up more than out, they can rise to over a thousand feet.

RUB AL KHALI, SAUDI ARABIA

GRAPHICS: LAWSON PARKER, NGM STAFF

WADI HAZAR • YEMEN Giant dunes appear to be crumbling into pieces, a puzzling phenomenon in the region's Empty Quarter. A change in wind patterns may explain the desert redesign.

**SAHARA ▪ ALGERIA** Villagers in an oasis near Timimoun erect fences made of palm fronds to protect their gardens from the shifting sand, which settles near the fences as the wind blows.

**NAMIB DESERT ▪ NAMIBIA** Sand repossesses buildings in Kolmanskop, a diamond-mining town abandoned in the 1950s. The ruins sit near an active sand stream that may someday bury them.

SAHARA • MAURITANIA. Travelling an old caravan route, tourists on camels weave through a maze of dunes. Sandstorms regularly push ridges around, continually creating an ever changing view.

A hidden camera captures a fleeting glimpse of an Asiatic cheetah. Only a few dozen survive in a remote corner of Iran. Worldwide cheetah numbers have plunged from an estimated 100,000 in 1900 to fewer than 10,000 today.

# CHEETAHS ON THE EDGE

Most vulnerable of the world's big cats, cheetahs are also one of its shrewdest survivors.

**By Roff Smith**
**Photographs by Frans Lanting**

Anticipation ripples through the crowd. Fingers tighten around binoculars. Camera lenses snap into focus. No fewer than 11 canopied safari buses, bright with tourists and bristling with long lenses, huddle near a solitary acacia tree in Tanzania's Serengeti National Park. For the past half hour a mother cheetah named Etta has been sitting in the shade with her four young cubs, eyeing a herd of Thomson's gazelles that drifted into view on a nearby rise. Now she's up and moving, sidling toward the herd with a studied nonchalance that fools no one, least of all the gazelles, which are staring nervously in her direction.

Suddenly one of the guides shouts, as the gazelles break and run and Etta launches into an explosive sprint. The sleek cat is too fast for the eye to follow, blurring through the grass like a bullet. The drama is over in seconds, ending with a puff of dust and a stranglehold on a luckless young gazelle. As Etta drags the carcass back to her cubs, they emerge from the scrub eager to tuck into the feast. The safari buses are only seconds behind, the drivers jockeying to get the best camera angles for their customers.

Cheetahs have come to occupy a curious place in the human imagination. Beautiful and exotic, sports car fast and famously docile, they are as much media stars as denizens of the wild, darlings of filmmakers and advertisers the world over. Tap "cheetah" and "images" into your computer's search bar, and more than 20 million results pop up—from fashion shoots to flashy car ads to photos of pet cheetahs riding in the backseats of Mercedes convertibles.

All this pop culture presence might create the impression that cheetahs are as secure in nature as they are in the popular imagination. They are not. In fact, cheetahs are the most vulnerable of the world's big cats, surprisingly rare and growing steadily rarer. A few centuries ago cheetahs roamed from the Indian subcontinent to the shores of the Red Sea and throughout much of Africa. As fleet of foot as they are, though, they couldn't outrun the long reach of humanity. Today the Asiatic cheetah, the elegant subspecies that once graced the royal courts of India, Persia,

*Roff Smith wrote about Australia's Fraser Island in September 2010. Frans Lanting has documented wildlife from the Amazon to Antarctica.*

**A nearly grown cheetah cub picks its way through a maze of safari vans in Kenya's Masai Mara National Reserve. Tourism, lions, and encroaching herds of cattle all add to the challenges of growing up on the African grasslands. Mortality rates for cheetah cubs can run as high as 95 percent.**

and Arabia, is all but extinct. In Africa cheetah numbers plummeted by more than 90 percent during the course of the 20th century, as farmers, ranchers, and herdsmen crowded the cats out of their habitat, hunters shot them for sport, and poachers captured cubs for the lucrative trade in exotic pets. In all, fewer than 10,000 cheetahs survive in the wild today.

Even within Africa's great game parks, cheetahs are under heavy pressure. Shy and delicately built, the only big cats that cannot roar, they are bullied into the margins by lions, which are far stronger both in body and number. Consider Tanzania's Serengeti National Park and the adjoining Masai Mara National Reserve in Kenya. Taken together the two parks are home to more than 3,000 lions, an estimated 1,000 leopards, and a mere 300 cheetahs. And despite their celebrity status, cheetahs lose out to lions in the tourism stakes as well. "Cheetahs tend to be something people look for on their second safari," says guide Eliyahu Eliyahu. "The first time around is all about seeing lions. The trouble is, where you have a big lion population, you will never have many cheetahs."

IF CHEETAHS SEEM a breed apart, it's because they are. Not only are they a separate species

**Cheetahs remain highly fashionable in Saudi Arabia and the Gulf states. "A rich, young man buys himself a cheetah to go with his sports car. It's typically a new-money thing."**
***—Mordecai Ogada***

from the other great cats, but they belong to a separate genus as well, a genus with just one member: themselves. Their genus name, *Acinonyx,* comes from Greek words for "thorn" and "claw" and refers to the cheetah's curious semi-retractable claw, a feature they share with no other cat. Unlike lions and leopards, whose fully retractable claws are tools designed for tearing flesh and climbing trees, cheetahs have claws that are more like the spikes on a sprinter's track shoe and serve a similar function: solid grip and quick acceleration.

Everything about a cheetah is designed for speed—pure, raw, explosive speed. Put a cheetah and a Lamborghini side by side on a freeway, and it will be an even-money bet which will smash the speed limit first. Both can do zero to 60 in under three seconds, but the cheetah can crack 45 miles an hour in the first couple of strides. And what strides. Thanks to its flexible spine and long, fluid legs, a cheetah can gobble up turf in bounds that exceed 25 feet. An elite human athlete who could leap that far even once, after a good run, would be well on his or her way to qualifying for the Olympic Games. A cheetah sprinting at top speed might be doing that up to four times a second.

Such superhuman abilities lent cheetahs an otherworldly aura in ancient times. Egyptians were the first people to tame them as pets and immortalize them in images on tombs and temples, nearly 4,000 years ago. In India, Iran, and Arabia, coursing with cheetahs—or "hunting leopards," as they were known—became an immensely popular sport among the aristocracy. In the courts of the Mogul emperors, cheetahs became a kind of motif, celebrated in paintings and tapestries, folklore and verse. Favorite cheetahs were adorned with jeweled collars and featured prominently in royal processions.

Cheetahs remain highly fashionable in Saudi Arabia and the Gulf states, where a cub can fetch upwards of $10,000. "A rich, young man buys himself a cheetah to go with his sports car," says Mordecai Ogada, a Kenyan wildlife biologist who has studied cheetah-human relationships and wildlife trafficking. "It's typically a new-money thing nowadays."

**Rescued as a cub from the hands of a poacher, five-year-old Koshki grew up in a reserve in northeast Iran. He's one of only two Asiatic cheetahs living in captivity. A thick tuft of fur on his shoulders, needed for bitter winters on the high steppes of central Iran, sets him apart from African cheetahs.**

In places such as the United Arab Emirates cheetahs occupy a kind of legal limbo. "The importation is clandestine," says Ogada, "but once there, the trade is open. Trafficked cheetahs can easily be 'laundered' and made to appear as though they were legally bred in captivity. It's difficult to determine the source of cubs unless you do genetic analysis and identify them as members of a subspecies that's endemic to a particular area."

How great a toll trafficking is taking on the world's dwindling cheetah population is anyone's guess, but evidence suggests that trade in wild cheetah cubs is a large-scale enterprise. Even a cursory trawl of the Internet turns up plenty of cubs being offered for sale by "breeders" in places like Dubai. Several cheetah smugglers were arrested last year in Tanzania and Kenya, and there were rumors of cheetah cubs being offered for sale as far afield as Cameroon.

"I suspect the problem is bigger than we imagine," says Yeneneh Teka, head of Ethiopia's Wildlife Development and Protection Directorate. "There is a great deal of money involved, and like the people who are smuggling drugs and guns, those who smuggle wildlife have well-established networks."

Last year Ethiopian authorities cracked down

# THE ANATOMY OF SPEED

Virtually every part of a cheetah's body contributes to the cat's undisputed title of fastest land animal. On the hunt, the ultimate sprinter accelerates to 60-plus miles an hour in three seconds, with bones, muscles, and major organs collaborating in a symphony of speed.

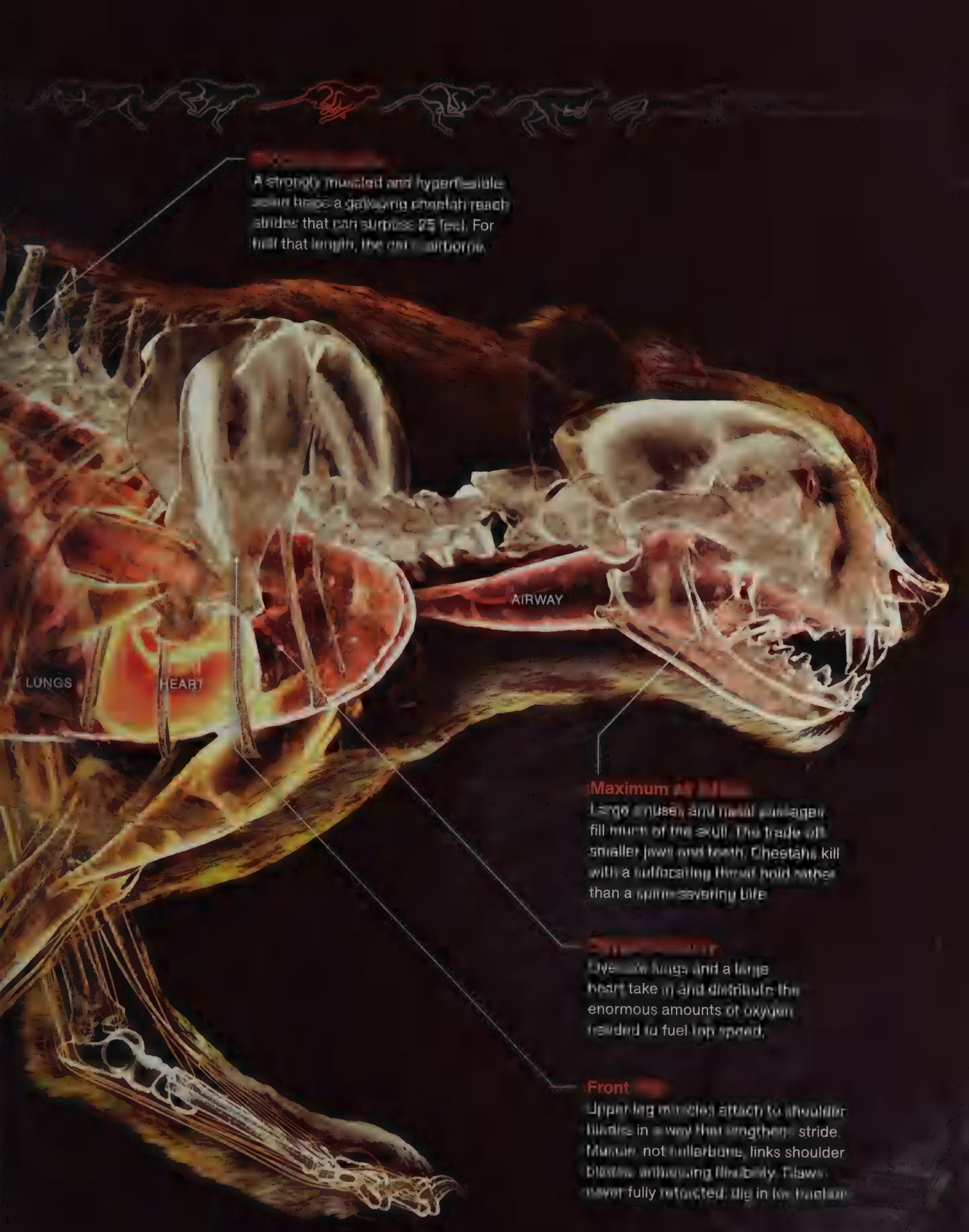
**Tail**

If pursued prey shifts direction, a cheetah turns just as quickly, aided by a tail that acts like a rudder.

**Back**

Long, slender bones increase stride length and take maximum advantage of each muscle contract[illegible] to propel at [illegible] the cat quickly kick into high gear.

## TOP SPEED OF FIVE LAND ANIMALS




A strongly muscled and hyperflexible spine helps a galloping cheetah reach strides that can surpass 25 feet. For half that length, the cat is airborne.

**Maximum air flow**

Large sinuses and nasal passages fill much of the skull. The trade-off: smaller jaws and teeth. Cheetahs kill with a suffocating throat hold rather than a spine-severing bite.

Oversize lungs and a large heart take in and distribute the enormous amounts of oxygen needed to fuel top speed.

**Front end**

Upper leg muscles attach to shoulder blades in a way that lengthens stride. Muscle, not collarbone, links shoulder blades, enhancing flexibility. Claws, never fully retracted, dig in for traction.

## THE CHASE

Top speed reached in three seconds can be sustained for 300 to 450 yards. Otherwise, the cat must rest 30 minutes or longer.

JASON STAFF, ART CHRISTIE. SOURCES: KRISTOFER M. MATTHEW W. TOCHERI, E. VEATCH, KATHRYN MCGRATH, NATIONAL OF NATURAL SMITHSONIAN PENNY ROYAL VETERINARY

**One supermom is known to have mothered at least 10 percent of all the adult cheetahs in the southern Serengeti. No other carnivore "relies so heavily on the success of so few females."**
***—Sarah Durant***

on wildlife smuggling and instituted a training program for border guards and customs officials. The stepped-up enforcement paid off when officials intercepted a consignment of cheetah cubs as they were being smuggled into Somalia.

"While the border guards were examining the truck's paperwork, they heard scratching sounds coming from a jerry can that was supposed to be full of petrol," Teka says. "When they opened it up, they found five tiny cheetah cubs in very poor condition." One of the cubs died. The other four, after weeks of veterinary care, were taken to a wildlife sanctuary operated by the Born Free Foundation an hour north of Addis Ababa, where they will spend the rest of their lives. Although it's a happy ending for the four survivors, it's a net loss for the species.

"They'll never be able to return to the wild," says Ogada. "Even if you could teach them to hunt, humans can't teach cubs how to recognize and avoid predators such as lions and hyenas." And although some cheetahs have been successfully rewilded on large, fenced reserves in South Africa, the wide-open grasslands are a far more dangerous place to grow up. Orphaned cubs "wouldn't stand a chance in a place like the Serengeti," says Ogada.

Even mother cheetahs find it difficult to raise cubs in the wild, where mortality among cubs can run as high as 95 percent. The great majority of cubs may never make it out of the den in which they're born. They're killed in raids by lions or hyenas, or they die of exposure, or they're abandoned by mothers that aren't skillful enough hunters to support them. Indeed, many female cheetahs go their entire lives without raising a single cub to maturity.

THERE ARE A RARE FEW, however, that somehow manage to beat the odds and enjoy astonishing success in raising cubs, some even fostering the offspring of other females. Superb hunters and wise in the ways of the bush, these supermoms manage to make a kill nearly every day while keeping their brood safe on the wide-open stage of the African grasslands, beneath the very noses of lions and hyenas. One such supermom, a seven-year-old named Eleanor, is known to have mothered at least 10 percent of all the adult cheetahs in the southern Serengeti.

"I'm not aware of any other carnivore whose survival relies so heavily on the success of so few females," says Sarah Durant of the Zoological Society of London. Durant directs the Serengeti Cheetah Project, one of the world's longest running carnivore studies. Now in its 38th year, the project has chronicled the lives and maternal pedigrees of generations of the Serengeti's cheetahs. It is hot, dusty work, involving long hours bouncing over the grasslands in hard-bitten Land Rovers seeking out the most elusive of Africa's great cats. It was Durant's painstaking research that revealed the vital importance of supermoms.

Though the matriarchal lines of the Serengeti's cheetah population are now well documented, paternity is another matter. Wildlife biologist Helen O'Neill waits patiently in her Land Rover a short distance from where three cheetah brothers—Mocha, Latte, and Espresso, known collectively as the Coffee Boys—lie sprawled in the shade of a ballanite tree. O'Neill is on what is delicately referred to as "poop patrol," collecting feces dropped by specific, identifiable cheetahs. Scientists at the Zoological Society of London are able to extract DNA samples and hope to fill in the paternal side of the Serengeti's family trees.

Analysis so far suggests that cheetah females are far more promiscuous than anyone suspected: In as many as half their litters, the cubs have different fathers. "We suspect this kind of multiple mating could have genetic benefits in

# A 7.19 second dash

That's all it took for Tommy T to cover 100 meters in a timed run at the Cincinnati Zoo. (A half second of his run is shown here.) Sarah, the fastest cheetah ever clocked, finished in 5.95. By comparison, Olympian Usain Bolt's record is 9.58.

*Cinematography by Greg Wilson*

An ultra-high-speed camera recorded this cheetah's run in high detail. See the video on our iPad and Kindle Fire editions.

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PHANTOM 4 AMERA ... EDWARD RICHARDSON, CAMERA OPERATORS: FRANK FUONO, SCOTT PROPKIN, GAFFER: MIKE GERSTEIN, KEY GRIP: TRAVIS

ASSISTANTS: BILL GOMEZ, PHOTO EDITOR: NGM STAFF, WALTER , NGM STAFF.

Traveling at 100 feet per second, a young male cheetah is airborne at the Cincinnati Zoo. In a single stride the agile cat strikes one paw after another on the ground, lifts completely into the air, and covers nearly 25 feet.



See cheetahs in action and learn the secrets of their speed on your tablet.

NATIONAL GEOGRAPHIC | BIG CATS

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OF BIG CATS.

**"Cheetahs have not been pushed into these mountains recently. They've been here for thousands of years. People don't realize how tough and versatile cheetahs really are."**
***—Luke Hunter***

patterns, we can identify them individually and work out their population and distribution."

All the same, saving the Asiatic cheetah will be a tall order. Its downfall traces back to the glory days of the Mogul Empire, when hunting with cheetahs became all the rage. One Mogul emperor is said to have collected more than 9,000 cheetahs during his 49-year reign.

Compare then and now. In ten years of setting out scores of cameras, Iranian researchers have so far managed to obtain a mere 192 fleeting images. Those images document 76 gaunt individuals, pretty much all that remains of a noble subspecies of cheetah that once roamed throughout much of Asia. Today's survivors eke out a precarious existence. Stalking antelope and mountain sheep on steep, stony slopes, they compete with wolves and even humans, for whom gazelles and sheep are also a handy food source.

"They are living on a knife edge, at the very limit of what is ecologically possible," says Luke Hunter, president of Panthera, an international conservation group dedicated to preserving big cats, and a collaborator on the Iranian cheetah project. "What's intriguing, though, is that these cheetahs have not been pushed into these mountains recently. They've been here for thousands of years. People don't realize how tough and versatile cheetahs really are."

Indeed they are. Despite their vulnerability, cheetahs are one of the world's hardiest and shrewdest survivors, enduring both the bitter winters of the Iranian steppes and the scorching heat of the Sahara wadis. "They are not just fast," says Algerian wildlife biologist Farid Belbachir, who has been setting camera traps in Algeria's Ahaggar Mountains, trying to capture images of the critically endangered Saharan cheetah. "They understand the landscape. They've figured out how to use the narrow parts of the wadis to launch their attacks, to give their prey less opportunity to escape."

BACK IN SERENGETI National Park, it's now in the shank of the afternoon, with the hot taste of dust in the air and thunderheads tumbling and billowing along the horizon. For the past hour or so Etta has been creeping up on a big male

**A young cheetah mother named Etta by researchers scans the Serengeti for signs of danger while her four 12-week-old cubs wrestle. A long-running study has found that the majority of cubs here are raised by a small group of cheetah supermoms.**

gazelle, drawing to within 40 yards of him, while he has remained oblivious to her presence.

"It's too early to tell if Etta is going to turn out to be a supermum," Durant says. "This is only her first litter. But the fact that she has brought four cubs out of the den and has raised them this far is an encouraging sign."

The gazelle is big and healthy, with a lot of meat on him. Etta takes another couple of quick, furtive steps forward, then crouches and waits, looking like a sprinter on the starting blocks, poised and ready for the gun.

A tense minute crawls by, then another. Suddenly, and seemingly for no reason at all, Etta just stands up and strolls away. Something doesn't feel right to her—a whiff of hyena on the breeze or maybe the scent of lions. Whatever it is, to a mother of four young cubs alone on the Serengeti, one fat gazelle isn't worth the risk. She beckons to her cubs to come along, and together they trot off into the violet haze. ▯

**BIG CAT WEEK**

In support of National Geographic's Big Cats Initiative, **Nat Geo WILD** presents ■ week of exotic felines. Prime time in December; check local listings.

A male cheetah assumes a lookout pose in a fig tree in Kenya's Masai Mara National Reserve. His prospects are sobering. Shy and aloof by nature, requiring vast spaces to live and hunt, the planet's fastest sprinters are in a race for their very survival.

A TRACTOR ROAD MUDDIED BY AUTUMN RAIN IN LEE COUNTY

# RETURN TO THE **ARKANSAS DELTA**

*The delta west of the Mississippi River was once a place where sharecroppers lived in segregation and poverty yet forged a vibrant community. Industrial farming has erased their culture, leaving behind endless sky and few people. Eugene Richards documented their world four decades ago. Now he returns to where his pictures began.*

By **Charles Bowden**

Photographs and Captions by **Eugene Richards**

A flashback strikes, and the photographer is once again walking across the field as our car drives down the two-lane road in the Arkansas Delta. "It had to have happened close to here," he says, and looks out the car window with sad eyes. Beyond the plowed ground are the remains of a sharecropper's shack that has been made irrelevant by the mechanical revolution of the past 70 years. "I'm walking with Dorothea across a plowed field to visit some people who lived in that shack," he says in his soft voice. "And then a crop duster sees me, sweeps down, and empties his tank of chemicals on us. She really gets drenched."

He stops. The woman who was with him at that moment became his wife. She later got breast cancer, and he always wondered if that shower of chemicals had something to do with it. The sun is bright, wisteria gone wild is climbing roadside trees, its lavender flowers hanging 40 feet in the air. The air is fresh with April, a hint of rain, and the stands of forest roar with spring. At dawn low clouds scud over the land, then the sun comes on, and the world begins again.

"That's it. That's all I can remember about that day."

The photographer is a white man who had come from Boston to the small town of Augusta during the civil rights era of the late sixties, and he now believes it was the most important time of his life. He was with VISTA (Volunteers in Service to America), working in a day-care center for black and white kids, and it wasn't long before his presence seemed to unsettle the white population of the town. His name is Eugene Richards, and because of an incident one night all those years ago, much about those days and nights is beyond his reach.

Memory comes and goes here on the delta, mainly goes.

THE ARKANSAS DELTA IS A SERIES OF RIVER basins that empty into the Mississippi from the west: the St. Francis, the White, and the Arkansas. Various agricultural systems have been tried here—slavery, sharecropping, industrial farming—all producing wealth for a handful amid widespread poverty. The ancient forests have been cut, many towns have dwindled into ghosts, and yet there is this one thing: The place still beckons, captures the heart, and persists like the blues songs that grew out of the pain and the rough-edged Saturday nights.

There are soft reasons for hope on the delta: the sentimental tug of the light at dawn, the scent of violent growth in the remaining woods, the lazy movement of the rivers across the pan of dirt. But none of this makes up for a hard history of poverty, lynchings, and an out-migration into cities because of a rejection by the delta itself.

The delta is the soul of the South, a place always becoming a New South and yet always shrouded in its past, a place that gave the nation the blues and harbored the Ku Klux Klan and in the sixties was a cauldron of social change that boiled up in young black people and spilled over to young white people all across the country.

*1970: I photographed the Landers sisters on the steps of Mount Calver Baptist Church of Christ, the makeshift chapel built by their preacher father in a shack in Rawlinson.*

Now it is a vast agricultural machine that has swept clean the land, that seems to hardly need people or towns.

Eugene Richards falls silent. We drive on. The flashback fades, the land remains, the place of the great river and the phantom chords of American memory.

THE SOIL HERE IS SOME OF THE MOST FERTILE in the world, but that has not been enough. Sixty million years ago the Gulf of Mexico extended all the way to Missouri. As the sea gradually withdrew, multiple rivers remained, including the Mississippi and its tributaries, which laid down deposits of deep soil, richer than dreams. Some 12,000 years ago the Ice Age ended, the glaciers melted, the rivers rose, and then came flood after flood, blanketing the delta of the mighty Mississippi. Annual flooding continued to build up the region's loamy, alluvial deposits, which measure a hundred feet deep in places.

American settlers arrived in the Arkansas Delta around 1800 and confronted a place of forbidding forests amid swamps, a different landscape from what you see today. A few decades later, as forests were cleared and swamps drained, the delta became a promised land. The plantation system took hold, though Arkansas generally lacks the big Greek Revival mansions of the movies. There simply wasn't enough time: The big plantation houses were just getting built here when the Civil War changed everything.

This chapter of Arkansas Delta history is written on the streets of Cotton Plant, a town of 649 people. In 1846 a man named William Lynch came over from Mississippi, threw up a house and store, and tried growing something relatively new for these parts. King Cotton began its reign. By then the Arkansas Delta was experiencing a period of dramatic growth. Steamboats on the Arkansas rivers could easily transport cotton to markets down in New Orleans. The state's estimated annual per capita income was $68—three dollars more than the national average. Slavery is what made the growth possible. By the outbreak of the Civil War some delta counties had more blacks than whites.

Today on Cotton Plant's main street the old Presbyterian church melts like wax in the sun. In front of the police station are two public benches, both chained. Old men sit in the shade by the dead downtown. "There used to be a veneer

*1970: A young marine home on leave stood at attention in front of a sharecropper shack where a field worker lived with his blind wife and two blind sons.*

**The Elaine massacre is one of the largest race killings of blacks in U.S. history, but few have heard of it. The past can be forgotten but not erased.**

plant, and it ran 24 hours a day," one old man told me. "Now everyone that works has to go somewhere else."

I AM SEARCHING FOR THE SITE OF THE ELAINE massacre, an event that began in a hamlet called Hoop Spur, three miles from the town of Elaine. In late September 1919 black sharecroppers held a meeting at a church in Hoop Spur to discuss how to get better prices for their cotton. The emancipation of slaves had destroyed the plantations' source of free labor and replaced it with the sharecropper system. After the Civil War newly freed slaves thought they could work as tenant farmers here and escape the repression of Dixie. That worked for a while.

There was gunfire at the sharecropper meeting, and when it ended, a deputy sheriff was wounded and a railroad security officer was dead. For days afterward mobs of whites roamed with guns and hunted blacks in the thickets. U.S. Army troops were called in and may also have done some killing. Whites called it a black insurrection; blacks called it a massacre by whites. No one agrees on the tallies. Perhaps five whites were killed. Estimates run from 20 into the hundreds of black men, women, and children dead. The bottom line: This is one of the largest race killings of blacks in U.S. history, but most people today have never heard of it. I stand in a field where Hoop Spur used to be. There are only plowed ground and rows of plants. Nothing in the fringe of trees tells tales of those days.

Maybe that is best. Things move on. Or maybe the past can be forgotten but not erased.

THE SLAUGHTER OF THE FORESTS ON THE Arkansas side of the Mississippi River lagged behind the felling of ancient hardwoods on the

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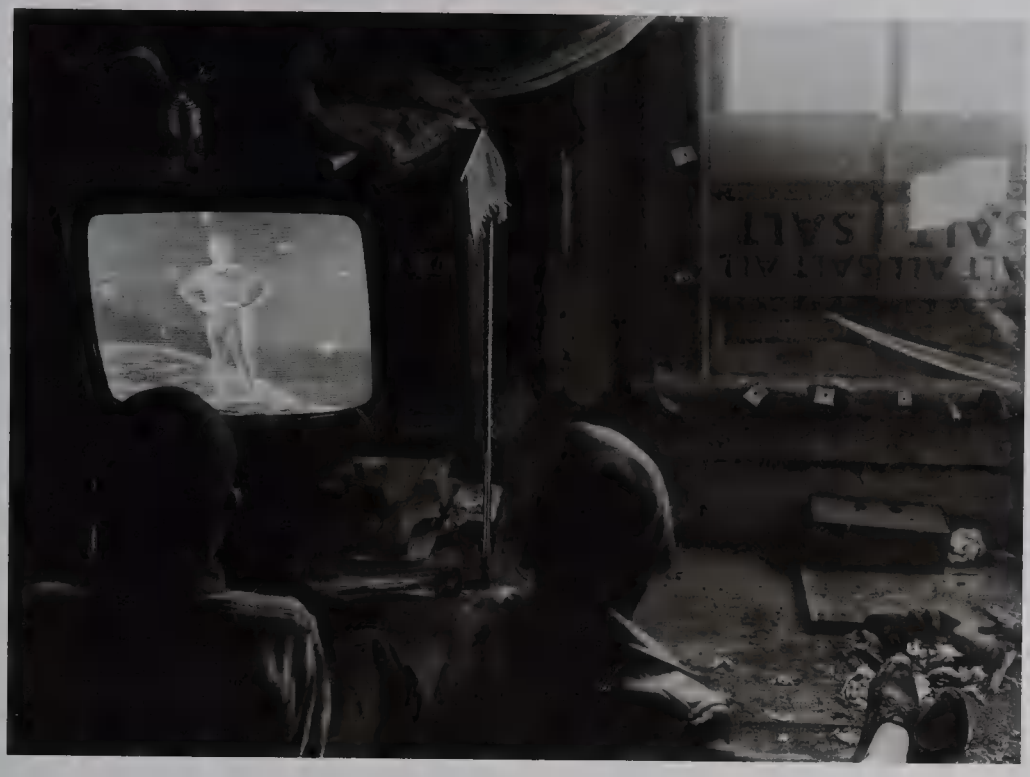
*Charles Bowden recorded oral histories in the Mississippi Delta in 1968, just miles from where Eugene Richards worked in Arkansas.*



*1971: On a freezing Saturday morning the Valentine children watched TV, though the plastic and cardboard on the windows barely kept out the wind and cold.*

east side. Not until the early 20th century did lumbering turn the delta into a moonscape of level fields. The towns along the lower White River and its tributaries beckoned sawmills and a fistful of woodworking factories. The town of Helena was a factory floor for lumber and wood veneer in the 1920s. It was an early booster of the dream of an industrialized New South that never came to pass.

In the 1940s and '50s, thanks to the *King Biscuit Time* radio show, Helena became the broadcast center for blues drifting across the delta. Juke joints boomed on Walnut Street, and whites secretly listened to the blues of Muddy Waters, Robert Nighthawk, and James Cotton on the radio. Then came the civil rights victories, and whites pulled their kids from integrated schools.

Now Helena-West Helena is a collapsed place—the final blow came on July 9, 1979, when Mohawk Rubber closed and took the last fat payroll with it. But there is an effort to make the town a cultural center, a shrine to the blues. Abandoned buildings say the place is over. The blues festival says it may come back. The morning light, the passing people who all say hello, the green vines that seem to devour all the work of human beings, the Mississippi River that licks the levees—these things insist that life goes on.

THE PHOTOGRAPHER IS NOT SURE WHAT happened. Eugene Richards was at his boardinghouse. There may have been a beating, he thinks. Maybe it was because two of his black female co-workers lived in the same boardinghouse he did. The only thing he knows for sure is that he ended up with seizures, possibly from a blow to the head, and was sent to a psychiatric hospital in Texas. When he spoke to his white landlady years later, she said she had caught someone pinning Ku Klux Klan crosses to the boardinghouse's gate but hadn't wanted to worry him.

There were other incidents: his dog, Mange, shot to death; lug nuts removed from the wheels of his girlfriend's car; a gun pulled on him and some black friends at a café; his face cut by a big white man with razor blades as Richards came out of a black church one Sunday. Two young VISTA volunteers were beaten bloody with broken coffee cups in a restaurant in nearby Hughes. The assailants reportedly thought the men were Richards and a co-worker.

Responding to the abject poverty and racial

violence he'd witnessed, Richards joined with other former VISTA volunteers, including a couple from Iowa named Earl and Cherie Anthes, to start an antipoverty organization called Respect, which published a tiny newspaper, *Many Voices.* Richards began to photograph the changes taking place. He covered Klan rallies, the aftermath of race killings, black people running for office.

Now the black-and-white photographs are what remain of his time there. There is a fog over those years in Arkansas. The blow to Richards's mind left shards of recollection separated by huge gaps, little fragments that drift up without warning, such as the memory of him crossing a plowed field with Dorothea, the woman who would become his wife and whom he would photograph as she succumbed to the cancer that would kill her.

**IN 1944 AT THE HOPSON PLANTATION ACROSS** the Mississippi River, an innovation in agricultural practices would have far-reaching effects on the Arkansas Delta. For the first time, an entire crop was harvested using a mechanized cotton picker, thereby ushering in an era in which one machine could replace more than a hundred hands doing brutal work in the fields.

This led to a second wave of the Great Migration, an exodus in the forties and fifties and sixties of more than five million blacks escaping poverty and illiteracy and discrimination in the Arkansas and Mississippi Deltas and the rest of the South for what they hoped was the true promised land of urban life. Showing the way was a sharecropper turned blues musician named Big Bill Broonzy, who had left Arkansas for Chicago in the 1920s and sang of his leave-taking in "Key to the Highway":

*I got the key to the highway,*
*And I'm billed out and bound to go*
*I'm gonna leave here runnin'*
*'Cause walkin' is most too slow.*

Everything here seems timeless, and yet all the changes came fast. By 1970 the sharecropping world was already disappearing, and the landscape of today—huge fields, giant machines, battered towns, few people—beginning to emerge. Today one person can farm 38,000 acres with only a dozen farmhands.

But the delta has something going for it that the rest of the nation has yet to fully learn. It is a place where race is always out on the table in plain view and is sometimes honestly discussed. A growing number of people here realize that the problems of the future won't be mastered unless race is put behind them—unless building communities with work, decent wages, and justice for all is put at the top of their agendas.

Gertrude Jackson is in her late 80s and spent her life on the delta. She'll take now over then. Especially since then was hard work with a hoe and the handcuffs of segregation: "As long as you don't have to go into the fields, it is a good day."

In the late sixties a utility pole outside her house near Marvell was shot at when she worked to end school segregation. Later she founded a community center. "When I was a kid, people didn't talk about the Elaine massacre. When civil rights people came, I heard about it." She has gray hair, wears black slacks and glasses. In her soft voice she says, "When you make up your mind to do something, you don't have any fear."

Ten of her 11 children have left—for Los Angeles, Virginia, Memphis, Baton Rouge, Georgia, the military: "There just wasn't anything here to do, so they went out." What is striking about her: She hasn't forgotten her struggle, but she seems to live in a state of grace without wounds.

Cherie Anthes and her husband, Earl, the former VISTA volunteers with whom Richards worked at the newspaper, never left the delta. She is a retired public health nurse; he still works in community development. They live in a world

Just west of the Mississippi River, the Arkansas Delta is 17 million acres of flat, fertile land laced with tributaries and dotted with towns in decline.

JEROME N. COOKSON, NGM STAFF

*1969: I drove out past the town of Marion beneath a quiet sky, as beautiful as anything I'd seen, to the house of a woman who lived by herself.*

they think has hit bottom, and in that fact they find hope. Earl thinks the divisions between whites and blacks, between owners and workers, don't matter anymore, because unless things get better for everyone, then it's over for everyone.

**The delta has something going for it: Race is always out on the table in plain view and is sometimes honestly discussed.**

OLLY NEAL IS PART OF THE PAST AND THE future. He is 71. In the early seventies he was a firebrand, a Vietnam vet and black organizer who carried a gun in self-defense, the guy who led a boycott of white businesses in Marianna and ran a VISTA-organized health clinic there. Now most of the stores downtown are closed, the factories gone. There are only a couple of juke joints in the whole county. Neal is a retired appellate judge who once worked in the courthouse in Marianna, which faces a square with a statue of Robert E. Lee.

Neal has hope. He cultivates the young, has sent a dozen locals to college. He believes they will someday return and fix the place.

Eugene Richards remembers Neal as one who inspired him but told him to leave the delta in the early seventies, said it was time for civil rights to be a black movement. It helped Richards realize his time was up. We are sitting in Neal's office when I mention this conversation. Neal snaps alert, looks over, and says, "Gene, was that you I told to go home?" and he gets up, and they embrace. Talk turns personal and emotional.

Neal and his brothers slaughter a steer each year for a barbecue. Gene must come down for this, he must. But for Richards, returning is complicated. In part because his time in Arkansas is still the burning core of his life. And in part because he left dispirited and confused about whether he'd accomplished anything at all. Now, 40 years later, the sharecropper life that he documented has slipped away. The place is less poor than it was and less rich at the same time. Whatever the South is, it stays with you, and whatever the delta is, it beats as the heart inside the South. □

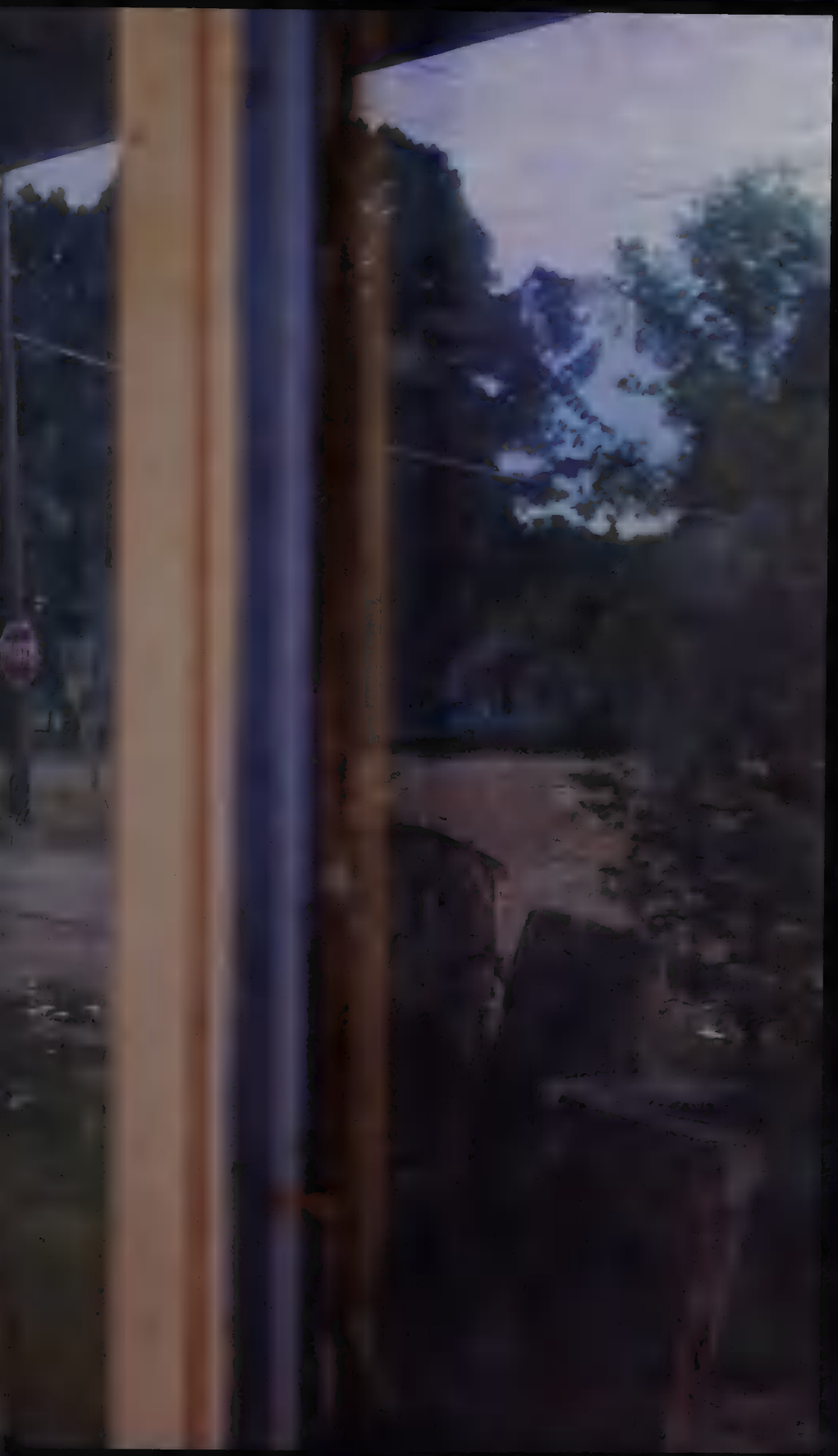
# ARKANSAS DELTA
# FINDING WHAT ENDURES

*Nobody needs to tell me that nothing stays the same. Still, what did I do when I returned to the Arkansas Delta after 40 years? What everybody does who tries to return to what was once home: search for what they knew. The first couple of days I drove maybe 500 miles looking for sharecropper shacks. There used to be hundreds of them, painted white and raised up on concrete blocks. Now there's not so much as a floorboard or a nail to mark where they were. It's as if the Mississippi had overflowed and swept them all away.*

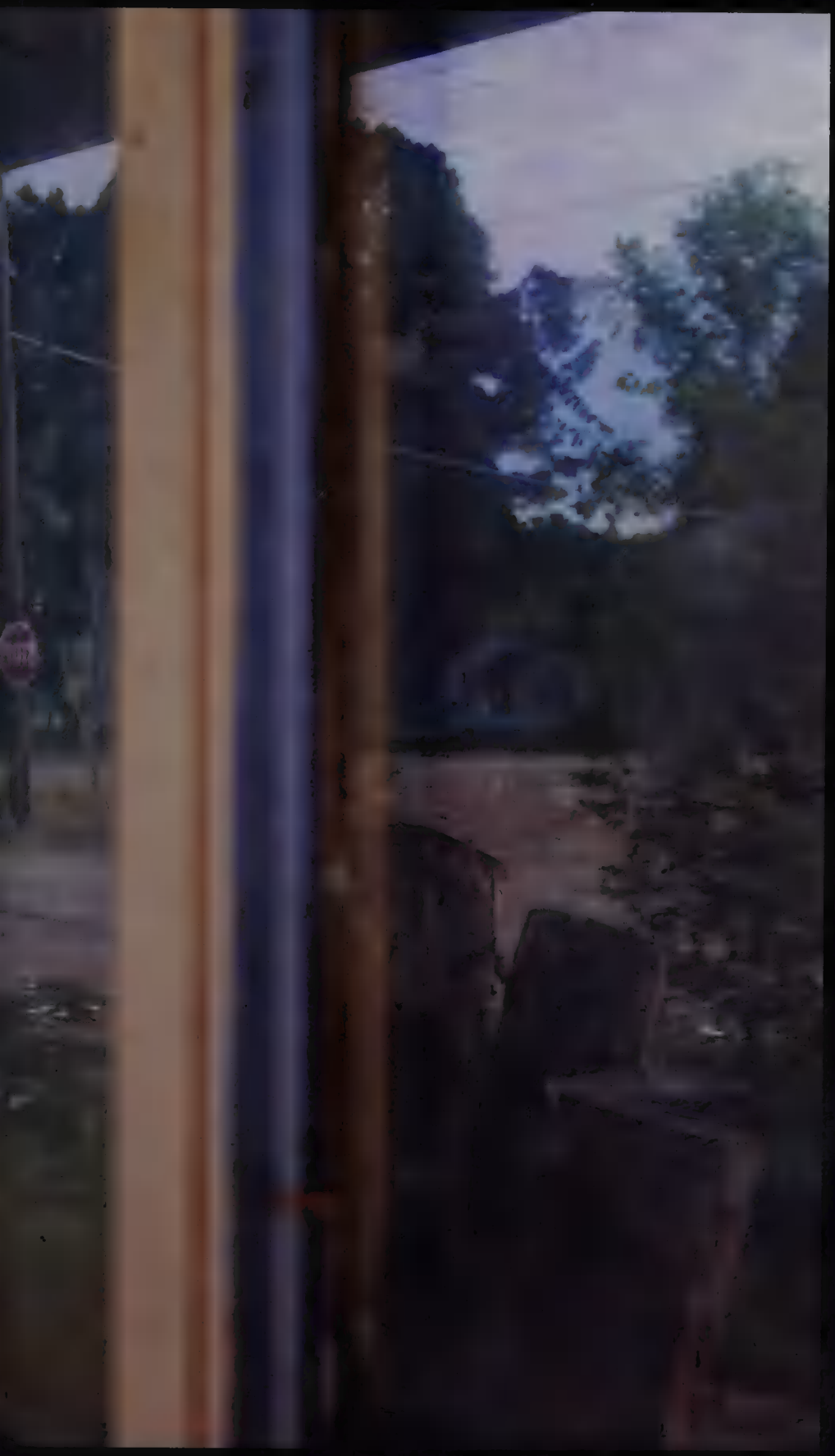
*It's hard to document the disappearance of a way of life, to capture the delta that once was and isn't today. I took pictures of church services, improbably small towns, monster tractors in the fields. Early one morning I was driving past a row of abandoned workers' houses north of Lehi when I spotted a pair of women's shoes on a porch. In a Lucite box, covered in ruby red glitter, they glowed like broken glass. After taking some pictures, I hid them behind an old couch. A month later I returned with my wife, Janine. Approaching the houses, we saw six or seven men step out of a white van, each wearing fragments of military uniforms. A man who was all muscles and tattoos told us they were U.S. Special Forces and that they'd taken over the houses for military exercises. Janine asked if he'd seen the red shoes. "You mean Dorothy's shoes," he answered, clearly knowing what she was talking about. We were then told to leave.*

*I ask myself now what the picture of the red shoes has to do with the story of the delta, then remind myself it's only when you stop trying to make sense of things that you start seeing.*

*—Eugene Richards*



*2010: I was driving away from the cotton gin in Widener when I caught sight of an elderly woman sitting on her porch. Her name was Viola Perkins, and when I asked if I could take her picture, she smiled, either happy to have a visitor or too polite to refuse. The photograph captures her reflection in the dusty window of her house.*



*2010: I was driving away from the cotton gin in Widener when I caught sight of an elderly woman sitting on her porch. Her name was Viola Perkins, and when I asked if I could take her picture, she smiled, either happy to have a visitor or too polite to refuse. The photograph captures her reflection in the dusty window of her house.*

*2010: The Peter's Rock Church in Marianna is no everlasting monument; it has been left to rot, its windows broken, its steeple fallen over. Still, I found it beautiful. Kneeling in the cemetery, listening to the insects hissing, watching as a dog wandered past, I felt history coming at me from all sides.*

IN MEMORY OF OUR LOVE ONE
Preston(Chris)Dotson
6-20-1955-8-14-2001
WE LOVE YOU

*2010: Jeannette Kern gently smoothed back the hair of her niece, Kequsha, who looked to be in her own private world yet aware of everything going on in her aunt's tiny house in Crawfordsville. Below, a tractor created an explosion of dirt and stones as a farmer south of Marianna dug shallow trenches to ready a field for growing rice.*

*The rural delta is almost emptied of people as farmworkers have been replaced by machines. Few old houses remain, most having collapsed or been torn down. I encountered one, above, hidden by trees. Below, close to sunset, I followed the Kern children as they walked home, stopping to pet their dogs, seeming to dance in the shimmering heat.*

# NG CONNECT

Every month this page features our staff picks of National Geographic Society products and events. For more go to *nglive.org*.

## NATIONAL GEOGRAPHIC ON TV

### Unlikely Animal Friends

What does a warthog see in a rhino? Find out this month on the National Geographic Channel, when improbable animal relationships are the name of the game. Discover why Mtani, a young Labrador retriever, can't get enough of Kasi, a six-month-old cheetah (left, playing together at Busch Gardens in Tampa, Florida), and get to know a seal and her favorite pal: an Irish veterinarian.

**BOOK**

**BIRD-WATCHER'S BIBLE** If the flutter of wings has ever caught your eye, this book is for you. It's a comprehensive yet lighthearted guide to all things avian, featuring bird-watching basics, essays, the history of birds in art, and more. In stores now ($40).

**EXHIBIT**

**PARADISE FOUND** Eight years ago photographer Tim Laman and ornithologist Edwin Scholes set out to document every bird of paradise species. See photos and videos from their expeditions at the National Geographic Museum starting November 1. (Visit *ngmuseum.org* for info.) Their book, *Birds of Paradise,* is on sale now.

**LECTURE**

**ANCIENT MAYA** Archaeologist William Saturno's discoveries have illuminated the Maya calendar. Hear him speak December 3 at the Goodman Theatre in Chicago, Illinois. Go to *nglive.org* for tickets.

**MAGAZINE**

**INNOVATION** This edition of *Exploring History* takes on great game changers of the past, including Ben Franklin, Leonardo da Vinci, and Martin Luther King, Jr. Available November 6 wherever books and magazines are sold or online at *ngm.com/history* ($6.99).

**Free Download of the Month**

**Bedouin Soundclash** *Light the Horizon*

On its latest album Bedouin Soundclash mines rich musical terrain. Merging Anglo rock and punk with reggae, Caribbean, and African sounds, this Canadian trio picks up where Bob Marley, the Clash, and the Police left off. For a free download from the group's album *Light the Horizon,* check out *natgeomusic.net/free.*



PHOTOS: STEVI CALANDRA (TOP); TIM LAMAN (BIRD)

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**Shooting Stars** Capturing the flight of emperor penguins in Antarctica is no easy feat. They rocket around underwater, then explode out of holes in the sea ice (below). To follow them, Paul Nicklen used polar survival skills he learned as a child living among the Inuit on Canada's Baffin Island. He read the ice and winds, and pressed the shutter even when he lost feeling in his fingers. Every so often, penguins burst from the water at this site, where Nicklen lay waiting. "They soared underwater like fighter jets in a dogfight," he says. "Then they'd fly out, land, push down with their bill, and stand up, going back to that slow, waddling bird. It was a privilege to see." *—Luna Shyr*

BEHIND THE LENS

## Penguins are pretty big. Did you worry one might hit you?

**PN:** I was hit once, quite hard in the head. I was in a safe place—out of their way—but a penguin went way off course, flew through the air, and landed on my head. He just casually stood up and walked away. A 70-pound bird to the head hurts a lot, but I'm lucky I've never been injured. I was also hit by a leopard seal. Its strategy is to fly out of the water and knock over penguins like bowling pins.

**How close were you to the penguins in this shot?**

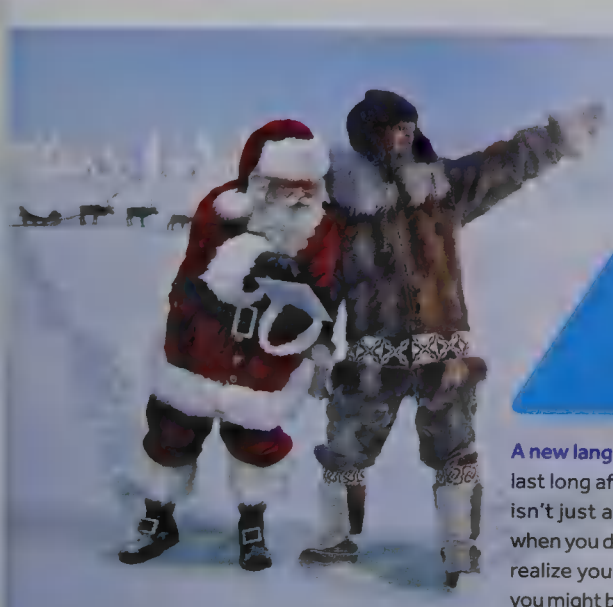
I was about three feet away. My camera was in a [protective] Seacam housing; they were sending up so much spray and ice it would've destroyed my camera. The noises and thuds when they landed on the ice were incredible. They knocked the air out of themselves and made a squeak. We were lucky in that there was really only one opening where the penguins entered and exited the ocean.

**Did you enjoy living with them?**

The first night in camp, the penguins followed me home. They stood outside and bugled all night. By the third night, I had a hard time sleeping, and the romanticism began to wane.



PHOTO: DEAN GUSHEE



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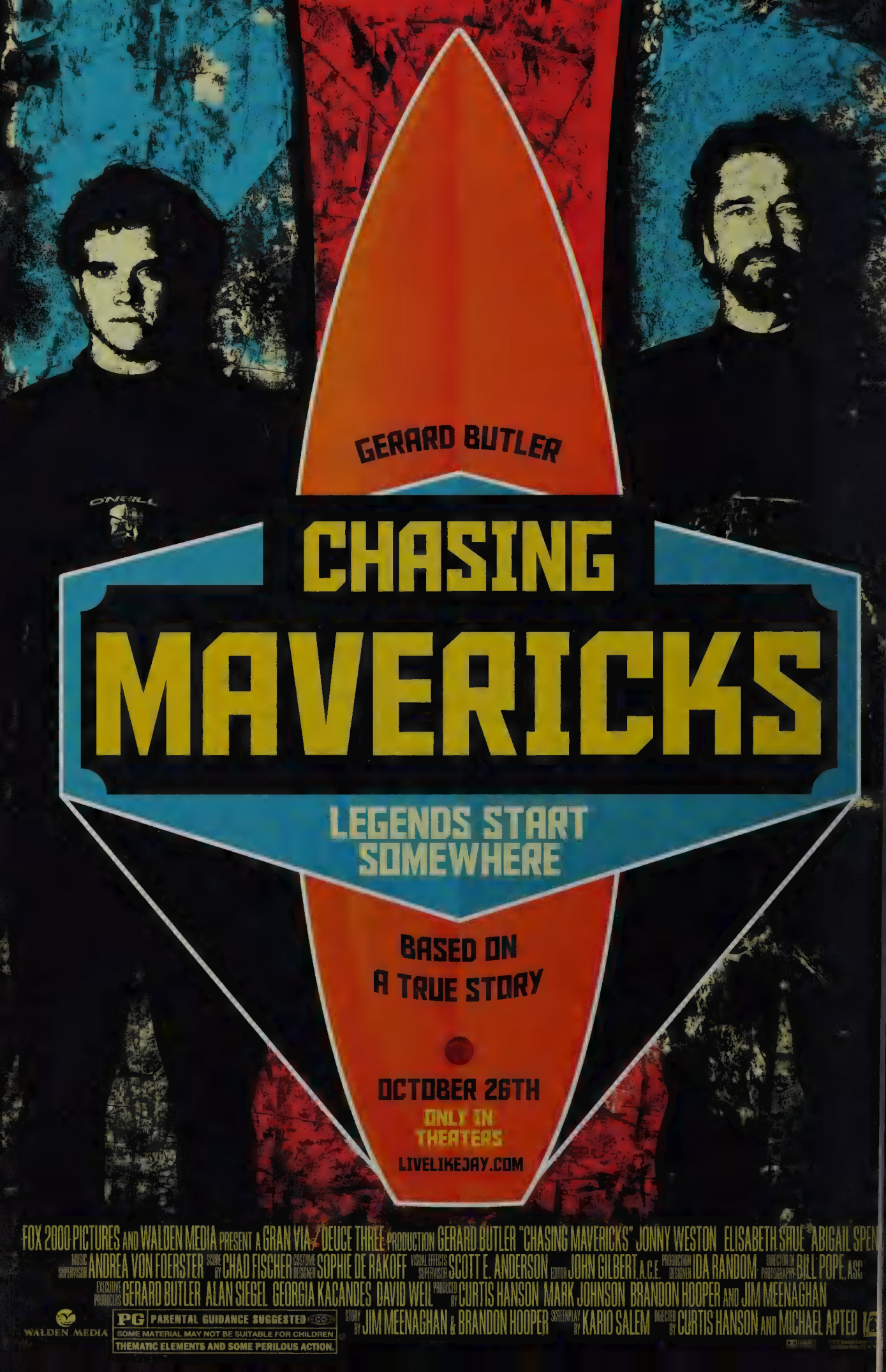
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NATIONAL GEOGRAPHIC

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**Head in the Sand** The Sphinx, Egypt's half-beast–half-man monolith, has often been buried up to its neck. It had been dug out at least three times by the time this photo was taken. The first was around 1400 B.C. by Pharaoh Thutmose IV, again during the Roman period, and a third time beginning in 1925—the same year as this photo—by Émile Baraize, a French engineer. In the summer of 1928 *National Geographic* Editor Gilbert H. Grosvenor warned his staff not to use this image, noting on the back: "As the Sphinx has been entirely uncovered, this picture is very much out of date."

But the photo's technology wasn't. Grosvenor had installed the first color printing lab in American publishing in 1920. Photographers processed their autochrome images in the field as glass plates and shipped them via steamer to the *Geographic*'s Washington headquarters. *—Johnna Rizzo*

**Flashback Archive** Find all the photos at **ngm.com.**

PHOTO: HANS HILDENBRAND, NATIONAL GEOGRAPHIC STOCK

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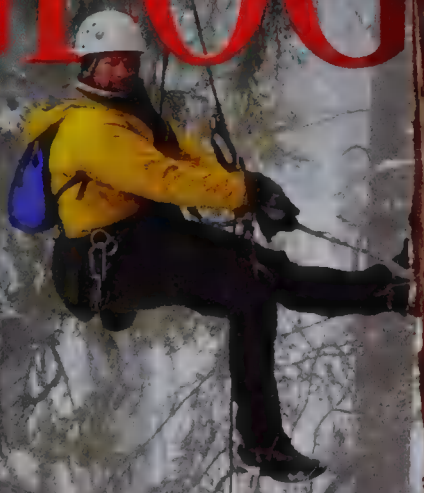

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The Tunnels of Gaza 42
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The Lost World of Doggerland 132

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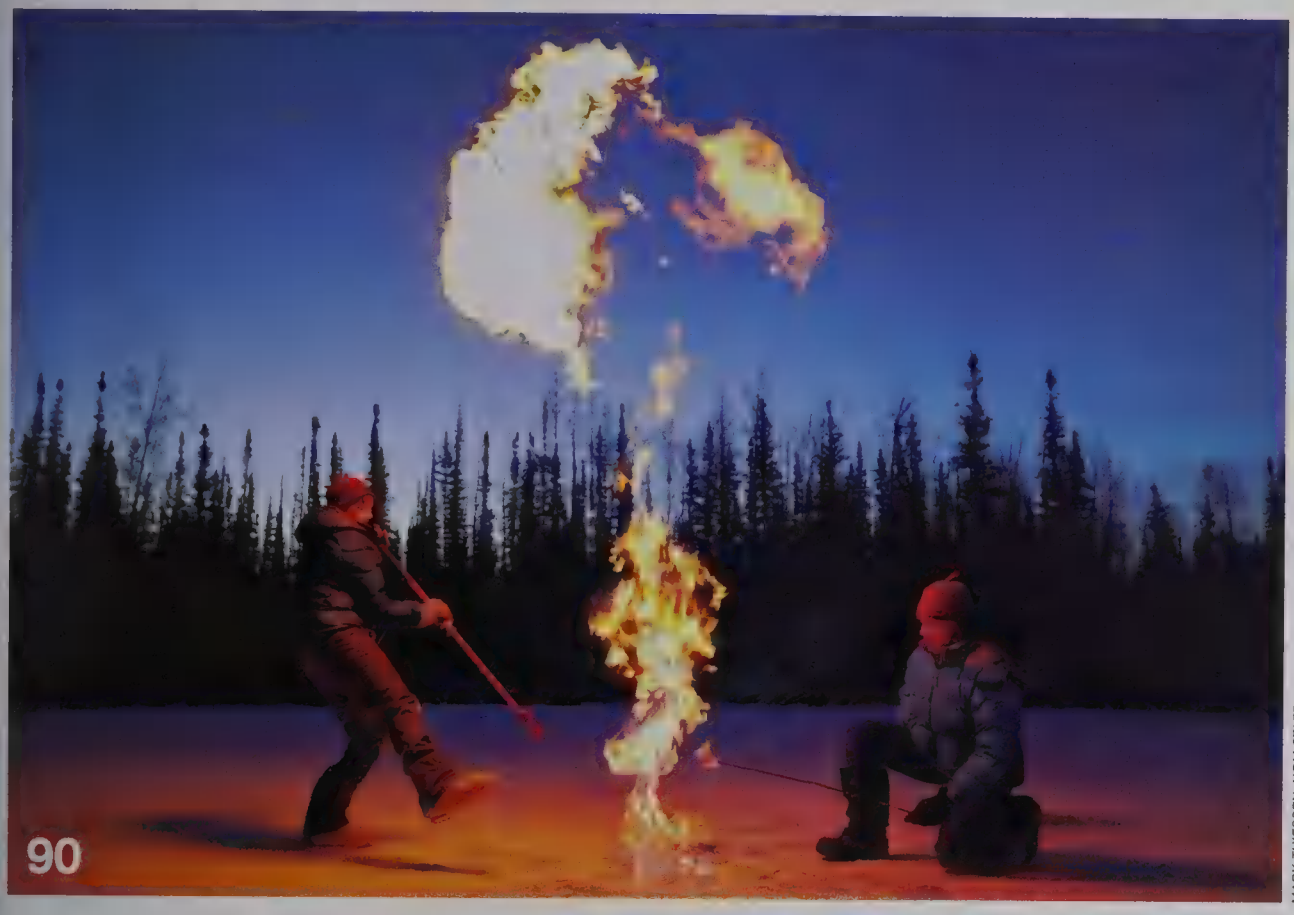
# NATIONAL GEOGRAPHIC

*One operator told of the time he tried to smuggle in a lion for a Gaza zoo.*
page 64




MARK THIESSEN, NGM STAFF

How to confirm there's methane trapped in an Alaska lake: pierce a pocket of ice with a spear, dangle a lit cotton swab over it. Escaping methane will create a flare.

## *December 2012*


### 28 Scaling a Forest Giant
A tree-climbing scientist takes the measure of a 3,200-year-old, 247-foot-tall sequoia.
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*By Mel White  Photographs by Tim Laman*

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*By Laura Spinney  Photographs by Robert Clark*

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**Popcorn Culture**
Fossilized cobs put the origin of the snack in Peru 6,700 years ago.

**Plastic Surgery**
The U.S. and Brazil lead the world but focus on different body parts.

**Tough Crossing for Jaguars**
In Latin America, highways and farms are blocking their path.

**Genes of a Tomato ▸**
It's got more than a human—and is a 92 percent match with the potato.

**Wooden Skyscrapers ▸**
The trendiest, greenest building material might just be timber.

**Hottest Year Ever**
Pass the sweatband: In the mainland U.S. there's a new record.

**New Life for Hotel Soap**
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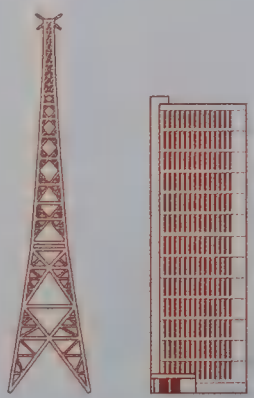


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Flashback

**On the Cover** For 17 days, a photographic team snowshoed 45 minutes through Sequoia National Park to reach the tree called the President, braving three blizzards. *Photos by Michael Nichols, NGM Staff*

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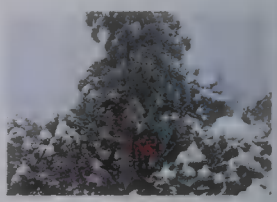
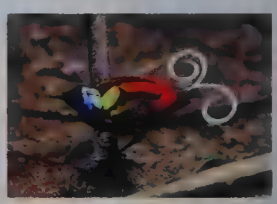


**Giant Sequoia**
Video
*Join the photographic team on a winter climb.*



**Birds of Paradise**
Video
*Get a bird's-eye view of the male's mating dance.*

**Top 10 NGM Photos**
Video
*Editor Chris Johns picks the best of 2012.*

PHOTOS: NATHAN WILLIAMSON (TOP); EDWIN SCHOLES (MIDDLE)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# The Snow Tree

It's practically a given among photographers that bad weather makes a better picture. It adds mood, nuance, and sometimes, mystery. In the case of the 3,200-year-old, 247-foot-tall sequoia known as the President—the centerpiece of our cover story on giant sequoias—it also added challenges and a few headaches.

The image of the snow-covered sequoia is a cousin of the photo of a 300-foot-high redwood tree on the foldout poster we ran in our October 2009 issue. It's a testimony to the passion of Michael (Nick) Nichols, who made both images, that no sooner had he finished photographing the redwood than he started wondering, What next?

**The stakes were raised. Nick planned to shoot in a blizzard.**

We wanted a different look this time, and the sequoia provided the platform. The stakes were raised. Nick planned to shoot in a blizzard. He envisioned a veil of white snowflakes softening the image of the tree.

Easier said than done. Every morning for 17 days, the team made a 45-minute trek to the site on snowshoes. Gear, including two heavy-duty batteries for power, had to be dragged in on sleds. The cold and wet caused technical difficulties. Picturesque snow sometimes turned to dreary rain. Still, Nick and his team succeeded.

"I wanted to honor the tree," he said.

He has.

Team members Jim Campbell Spickler (left) and Giacomo Renzullo stretch while working on the tree.



PHOTO: MICHAEL NICHOLS, NGM STAFF

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## In the Shadow of Wounded Knee

The Oglala used to thrive in that country because it gave them the richness of the prairie. They lived where the buffalo lived, and the buffalo gave them food, robes, a fierce and exciting occupation, and a spiritual connection to the land. Others killed off almost all the buffalo and with their guns squeezed the people into a small corner of the buffalo range. The land was amputated and the heart torn out. Now the people live on the body of a corpse. How can we restore the spirit of the buffalo? Perhaps we should restore the buffalo.

**CHRIS TOLKING**
**Sherborn, Massachusetts**

As a former history teacher, I find it curious that Alexandra Fuller groups the recognizable places of Auschwitz and Nanjing with Robben Island. When discussing the slaughter of innocent people, why does she not instead refer to Soweto? Many black students were killed during the Soweto uprising, though not on the scale of Nanjing or Auschwitz. Most of us recall Robben Island as the place of Nelson Mandela's incarceration but not as a killing field.

**MORRIE SCHNEIDER**
**Fresno, California**

Alexandra Fuller's article contains several quotes from Native Americans but omits what is probably the most evocative of all said in relation to their relationship with the whites. A Sioux elder said of the white man: "They made us many promises, more than I can remember, but they never kept but one; they promised to take our land and they took it."

**COLIN WILLSHER**
**Eye, England**

The author uses the term "medicine man," an American-English term I think has connotations that belong to the last century. I prefer the terms "spiritual or native healer" because many native healers use cultural methods such as prayers, brushing with eagle feathers, lighting incense, and others that are understood in the native cultures in ways that the term "medicine" does not cover.

**THOMAS H. JOHNSON**
**Stevens Point, Wisconsin**

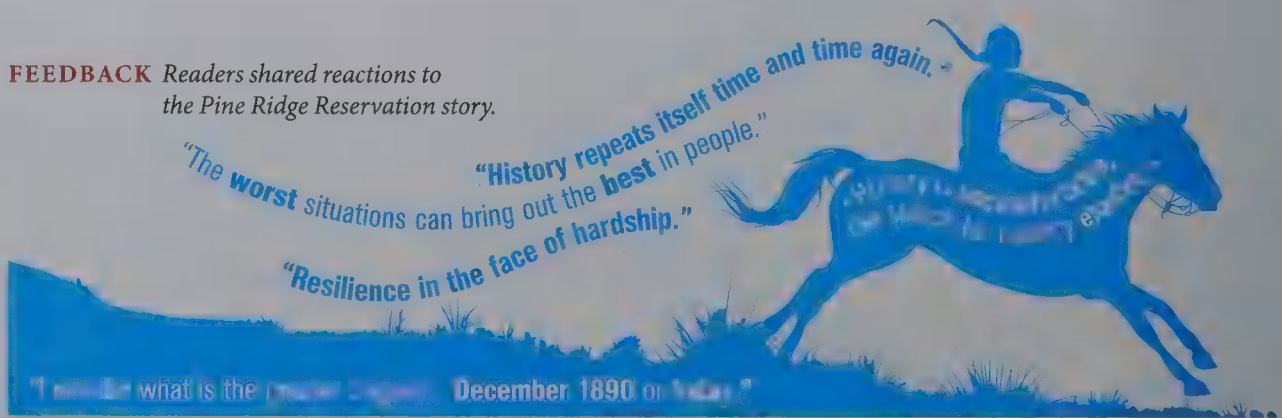
The Lakota seem to center attention on how they have battled and warred (and lost). They could heal their culture if they could learn how to make peace with their greatest enemy: themselves.

**HOLLY SCHMIDT**
**Clarinda, Iowa**

**Corrections**

**AUGUST 2012, NOW: PHONE BOOTHS**
Guitarist Brian May continues to perform with the rock band Queen.

**FEEDBACK** *Readers shared reactions to the Pine Ridge Reservation story.*


"The worst situations can bring out the best in people."
"History repeats itself time and time again."
"Resilience in the face of hardship."
December 1890

**EMAIL** ngsforum@ngm.com **TWITTER** @NatGeoMag **WRITE** National Geographic Magazine, PO Box 98199, Washington, DC 20090-8199. Include name, address, and daytime telephone. Letters may be edited for clarity and length.



GRAPHIC: JOSHUA MAXWELL

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My fascination with the lives of American Indians grew from the *National Geographic* magazines my grandmother brought with her to Italy when she visited us before WWII. Americans should be proud of them, but instead, sadly, they don't seem to fit in.

**GIULIANA DOOLEY**
**Richmond, Virginia**

Honoring one's forefathers is commendable, but trying to live in their world is not reasonable.

**BILL LAUDEMAN**
**Chattanooga, Tennessee**

**Americans should be proud of them, but instead, sadly, they don't seem to fit in.**

I am a full-blooded Ho-Chunk. I was taken aback by your article because there were some pictures that were offensive to me as a Sun Dance leader, spiritual leader, medicine person, and spokesperson for the Grey Eagle Society. I was taught that sacred or ceremonial practices of any type were not to be photographed, much less published in a magazine. I consider this an invasion of our sacred ways.

**MICHAEL DAY**
**Viroqua, Wisconsin**

*Photographer Aaron Huey responds: During my seven years of travels to Pine Ridge, two spiritual leaders (appearing both in the print article and in video interviews in our digital editions) of separate spiritual communities have been generous enough to educate and mentor me. They were among the first people I had meaningful relationships with on the reservation. Permission to photograph their ceremonial spaces was always asked before any images were made. And once permission was given, it was communicated to the other members of their communities. They also granted me clearance to publish selected images.*

*The* heyoka *in the ritual on pages 32-33 is a close friend of mine. He allowed me to make that intimate photograph. One thing that became clear to me after seven years of working on Pine Ridge is that each spiritual leader and each community has an individual vision, and they maintain the right to interpret that vision as they wish.*

## Tibet's Golden "Worm"

I am curious about the sustainability of the *yartsa gunbu* harvest. How do some of the larvae escape infection by *Ophiocordyceps sinensis* while others fall victim to the parasitic fungus. Are some immune?

**MARIS SOVOLD**
**Seattle, Washington**

*Scientists still don't know the answer. But several laboratories affiliated with Beijing's Chinese Academy of Sciences are currently researching parasitism of ghost moths by the fungus.*

## East London

Your implied answer as to whether the inner-city region (in which I have lived most of my adult life) is to be reborn may be the optimistic hope of naive outsider anthropologists. But it by no means represents the consensus among most hardheaded, experienced locals.

**IAN-RAY-TODD**
**London, England**

The luminous topping on author Cathy Newman's pie and mash is called liquor sauce.

**HARRY HARRIS**
**Maidenhead, England**

## Photographing Storms

What a wonderful surprise to read the description of the camera (Kahuna) that Tim Samaras uses to try to catch lightning strikes. My father, Willard Buck, designed the camera when he worked at Los Alamos right after the war, to take pictures of aboveground nuclear tests. Not the kind of thing you bring home, but my father used to test the mirrors in the basement sometimes.

**CORNELIA ALLEN**
**Fredericksburg, Texas**

## Gannets

Am I the only one who saw Salvador Dalí reincarnated as a gannet on pages 68-69?

**JOSEPH LOSINSKI**
**North Pole, Alaska**

## NOW: Phone Booths

Just a thought, but maybe someone could refit these old icons as Wi-Fi hot spots and mobile charging stations for cell phones. They could then be back in the public and serve a purpose.

**DAVID IVORY**
**Covington, Kentucky**

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NATIONAL GEOGRAPHIC MAGAZINE

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# VISIONS

**Afghanistan**
Overnight snowfall slows the pace of a Monday-morning commute in residential Kabul. The street is lined with flags heralding the opening of the Afghan parliament.

PHOTO: MUSADEQ SADEQ, AP IMAGES

STOP

**Russia**
Rosy from the bitter cold, the children of reindeer herders pause during play on the windswept tundra of Russia's Yamal Peninsula. Their coats, called *malitsas*, are sewn from reindeer hide, with the fur facing inward.

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**United Kingdom**
A merlin turns momentarily from the snipe in its grip after an attack on moorland near Whitby, in northern England. The raptor eats small birds, along with occasional mammals and insects.

PHOTO: STEVE MILLS

This page features two photographs: one chosen by our editors and one chosen by our readers via online voting. For more information, go to *ngm.com/yourshot*.

**EDITORS' CHOICE** **Li Xin** Beijing, China

One summer evening Li was snapping shots of clouds from his Beijing rooftop when lightning (at center left) lit up this towering thunderhead. The effect, says the 31-year-old photojournalist, reminded him of a mushroom cloud from a nuclear explosion.

**READERS' CHOICE**

**Lisa Franceski**
Glen Cove, New York

Ever mindful not to disturb baby birds, Franceski crawled through goose poop to photograph this flapping gosling at a pond on Long Island, New York. "I couldn't stop laughing," says the registered nurse, 48. "It looked like a football referee calling, Touchdown!"

A STAR ALLIANCE MEMBER

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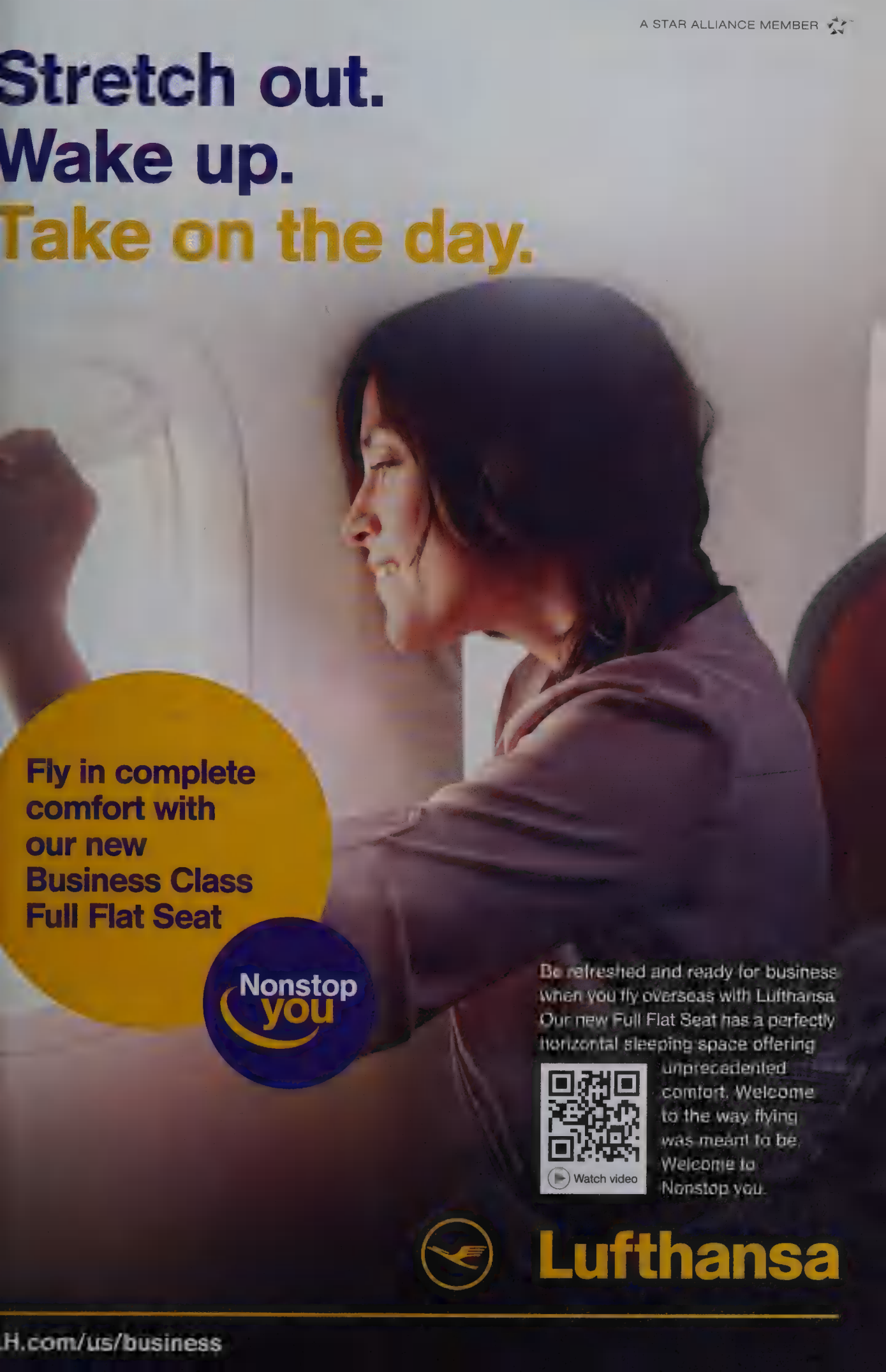
# Wake up.
# Take on the day.



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# Winning Photos

More than 20,000 images were submitted to the 2011 annual National Geographic Photography Contest, representing more than 130 countries. Our judges selected images by Shikhei Goh, George Tapan, and Izabelle Nordfjell as winners in the categories of nature, places, and people. The grand-prize winner received $10,000 and a trip to National Geographic headquarters in Washington, D.C.

For more information, go to *ngphotocontest.com.*

NATURE AND GRAND-PRIZE WINNER
**Shikhei Goh**
Batam, Indonesia

Aided by a water-spraying friend, Goh sought to capture the magic of a dragonfly in rain. He titled the image "Splashing."

PLACES **George Tapan**
Muntinlupa City, Philippines

Windblown hair and a fisherman's boat infuse serenity into this scene from Onuk Island. The moment of calm—and rainbow—followed a storm.

PEOPLE **Izabelle Nordfjell**
Örnsköldsvik, Sweden

A Sami man prepares to take aim at a reindeer in northern Sweden as his son braces for the shot. The successful hunt provided food for the winter.

ons shown.

TOYOTA

prius family

and ©2012

The coal-fired Drax plant in North Yorkshire is the United Kingdom's largest power station.

## Industrial Wonderland

Dozens of power stations dot the English countryside. Like many people who live here, I find them oddly beautiful: architecturally alluring icons of our past that burn fossil fuels, polluting the present. Since 2008 I've explored that double layer of symbolism by photographing them at night, using large format and long exposures to show the ceaseless production occurring on the fringes of our landscape—and consciousness.

Before this series I was fishing for a timely topic that would clarify things for me as an artist. I've found it here, as well as a personal confluence. For instance, I used to do recon work in an infantry regiment; while I never trespass to get a shot, I did draw on that experience to scout locations. And I used to study environmental science, so it's somehow fitting that polluting structures are my subjects.

Personally I'm an advocate of renewable energy, but I don't see this project as an ideological pulpit. I want to document the issue and raise awareness, but let people form their own opinions. All the power plants I've shot in this series are unsustainable, yet they still serve our ever growing needs. I aim to illuminate that complicated relationship between power generation and the environment.

### THE PHOTOGRAPHER

*Toby Smith is a London-based photographer for Reportage by Getty Images who focuses on sustainability and environmental issues. He publishes and exhibits internationally.*

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*ase see Important Risk Information for Lyrica on the following page.*

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This swelling can be a serious problem with people with heart problems.

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- Anyone who is allergic to anything in LYRICA

## BEFORE STARTING LYRICA

Tell your doctor about all your medical conditions, including if you:

- Have had depression, mood problems or suicidal thoughts or behavior
- Have or had kidney problems or dialysis
- Have heart problems, including heart failure
- Have a bleeding problem or a low blood platelet count
- Have abused prescription medicines, street drugs or alcohol in the past
- Have ever had swelling of your face, mouth, tongue, lips, gums, neck, or throat (angioedema)
- Plan to father a child. It is not known if problems seen in animal studies can happen in humans.
- Are pregnant, plan to become pregnant or are breastfeeding. It is not known if LYRICA will harm your unborn baby. You and your doctor should decide whether you should take LYRICA or breast-feed, but not both.

Tell your doctor about all your medicines. Include over-the-counter medicines, vitamins, and herbal supplements. LYRICA and other medicines may affect each other causing side effects. Especially tell your doctor if you take:

- Angiotensin converting enzyme (ACE) inhibitors. You may have a higher chance for swelling and hives.

## BEFORE STARTING LYRICA, continued

- Avandia® (rosiglitazone)*, Avandamet® (rosiglitazone and metformin)* or Actos® (pioglitazone)** for diabetes. You may have a higher chance of weight gain or swelling of your hands or feet.
- Narcotic pain medicines (such as oxycodone), tranquilizers or medicines for anxiety (such as lorazepam). You may have a higher chance for dizziness and sleepiness.
- Any medicines that make you sleepy

## POSSIBLE SIDE EFFECTS OF LYRICA

LYRICA may cause serious side effects, including:

- See "Important Safety Information About LYRICA."
- Muscle problems, pain, soreness or weakness along with feeling sick and fever
- Eyesight problems including blurry vision
- Weight gain. Weight gain may affect control of diabetes and can be serious for people with heart problems.
- Feeling "high"

If you have any of these symptoms, tell your doctor right away.

The most common side effects of LYRICA are:

- Dizziness
- Blurry vision
- Weight gain
- Sleepiness
- Trouble concentrating
- Swelling of hands and feet
- Dry mouth

If you have diabetes, you should pay extra attention to your skin while taking LYRICA and tell your doctor of any sores or skin problems.

## HOW TO TAKE LYRICA

Do:

- Take LYRICA exactly as your doctor tells you. Your doctor will tell you how much to take and when to take it. Take LYRICA at the same times each day.
- Take LYRICA with or without food.

Don't:

- Drive a car or use machines if you feel dizzy or sleepy while taking LYRICA.
- Drink alcohol or use other medicines that make you sleepy while taking LYRICA.
- Change the dose or stop LYRICA suddenly. You may have headaches, nausea, diarrhea, trouble sleeping, increased sweating, or you may feel anxious if you stop taking LYRICA suddenly.
- Start any new medicines without first talking to your doctor.

## NEED MORE INFORMATION?

- Ask your doctor or pharmacist. This is only a brief summary of important information.
- Go to **www.lyrica.com** or call **1-866-459-7422 (1-866-4LYRICA).**

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**Rx only**

# How to Outsmart a Millionaire

*Only the "Robin Hood of Watchmakers" can steal the spotlight from a luxury legend for under $200!*

Mr. Bigshot rolled up in a roaring high-performance Italian sports car, dropping attitude like his $22,000 watch made it okay for him to be rude. That's when I decided to roll up my sleeves and teach him a lesson.

"Nice watch," I said, pointing to his and holding up mine. He nodded like we belonged to the same club. We did, but he literally paid 100 times more for his membership. Bigshot bragged about his five-figure purchase, a luxury heavyweight from the titan of high-priced timepieces. I told him that mine was the ***Stauer Corso, a 27-jewel automatic classic now available for only $179.*** And just like that, the man was at a loss for words.

**The Stauer *Corso* is proof that the worth of a watch doesn't depend on the size of its price tag.** Our factory spent over $40 million on Swiss-made machinery to insure the highest quality parts. Each timepiece takes six months and over 200 individual precision parts to create the complex assembly. Peer through the exhibition back to see the 27-jeweled automatic movement in action and you'll understand why we can only offer the ***Corso*** in a limited edition.

**Our specialty is vintage automatic movements.** The ***Corso*** is driven by a self-winding design, inspired by a 1923 patent. Your watch will never need batteries. Every second of power is generated by the movement of your body. The black dial features a trio of date complications including a graphic day/night display. The ***Corso*** secures with a two-toned stainless steel bracelet and is water-resistant to 3 ATMs.

**Your satisfaction is 100% guaranteed.** Test drive the Stauer ***Corso***. If you don't love it, send it back within 30 days and we'll refund every dollar of your purchase price. Spending more doesn't make you smarter. But saving thousands on a watch this stunning will leave you feeling (and looking) like a genius!

***Exclusive OFFER!***

*Order the Stauer Corso and these Stauer Flyboy Optics™ Sunglasses (a $99 value) are yours* ***FREE****!*

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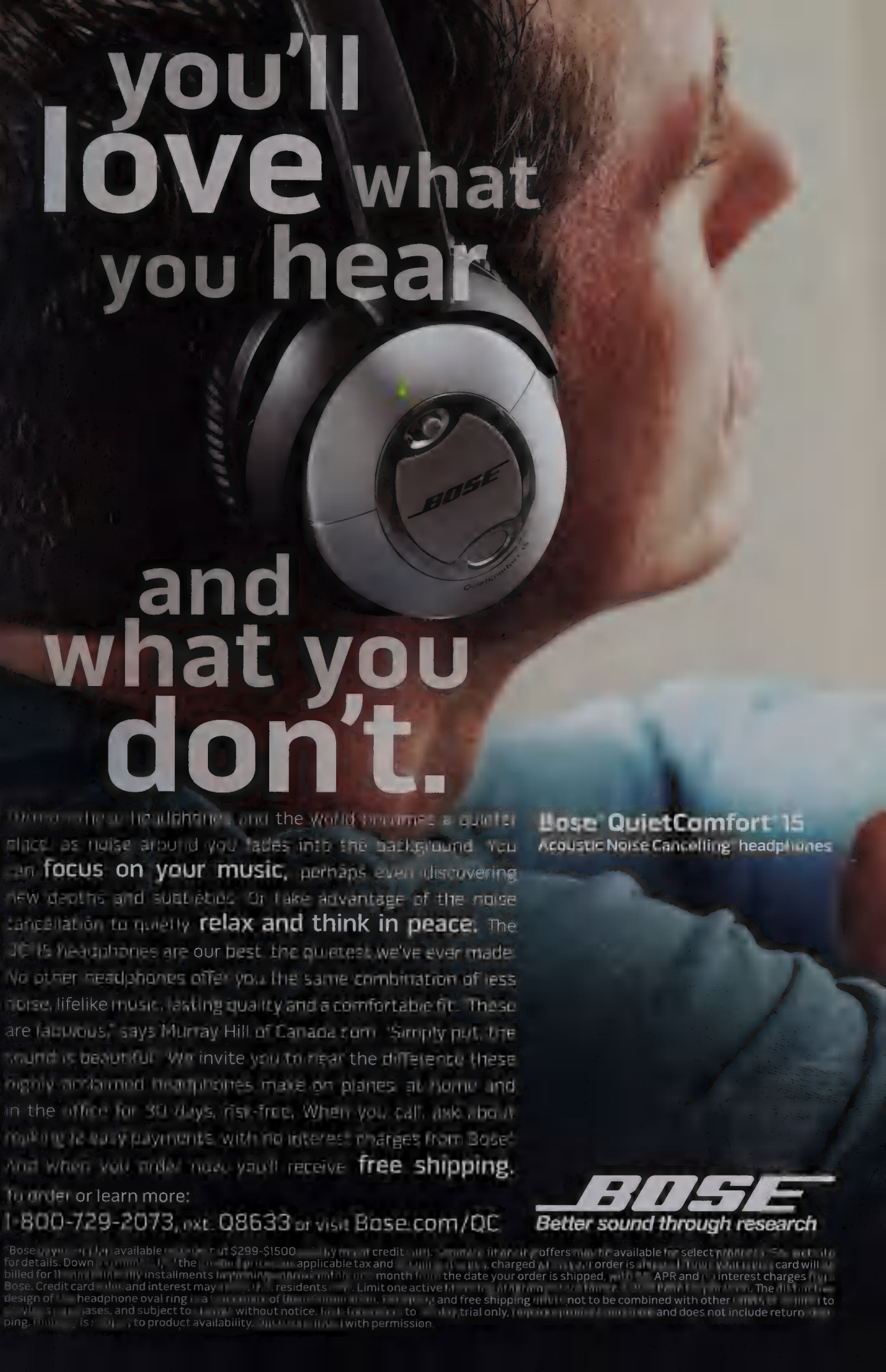
Jeweled Vertex automatic movement - Interior dials - Transparent caseback - Dual-toned stainless steel case and bracelet band fits wrists 6 ½"–9"

Killingholme is a natural gas plant in North Lincolnshire. It was built in the 1990s, with a modern design and grassy grounds. I found this vantage point in the mature woodlands like those that once blanketed the site.

More than 40 years old, the Fawley station in Hampshire is considered one of England's most efficient oil-fired plants. Stabilizing my camera is one of the biggest photographic challenges I face, since a gust of wind will ruin a shot. I find that heavy tripods are essential.




Put on these headphones and the world becomes a quieter place, as noise around you fades into the background. You can **focus on your music**, perhaps even discovering new depths and subtleties. Or take advantage of the noise cancellation to quietly **relax and think in peace.** The QC 15 headphones are our best, the quietest we've ever made. No other headphones offer you the same combination of less noise, lifelike music, lasting quality and a comfortable fit. "These are fabulous," says Murray Hill of Canada.com. "Simply put, the sound is beautiful." We invite you to hear the difference these highly acclaimed headphones make on planes, at home and in the office for 30 days, risk-free. When you call, ask about making 12 easy payments with no interest charges from Bose®. And when you order now, you'll receive **free shipping.**

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1-800-729-2073, ext. Q8633 or visit Bose.com/QC

Bose payment plan available on orders of $299-$1500 made by most credit cards. Separate financing offers may be available for select products. See website for details. Down payment, if any, the monthly payment amount, applicable tax and shipping charges, charged when your order is shipped. Your credit card will be billed for the monthly installments beginning approximately one month from the date your order is shipped, with 0% APR and no interest charges from Bose. Credit card offer and interest may vary for residents of some states. Limit one active financing offer from Bose per purchase. The distinctive design of the headphone oval ring is a trademark of Bose Corporation. Free shipping and free shipping offers not to be combined with other offers or applied to prior purchases, and subject to change without notice. Risk-free period refers to in-home trial only, begins on purchase date and does not include return shipping. Availability is subject to product availability. Offer void where prohibited. Used with permission.

Ratcliffe-on-Soar, a coal-fired station I shot in this five-and-a-half-hour exposure, can generate enough electricity for some two million people. It's loomed over Nottinghamshire for 40-plus years, yet people rarely give it ■ second glance.

Oxfordshire's Didcot stations—■ natural gas plant and an adjoining one that burns gas and coal—glow across ■ ripe cornfield in this one-hour exposure. The British poet Kit Wright once wrote a tongue-in-cheek "Ode to Didcot Power Station": "Thy consummate immensity / Enshrines the rare propensity / Of fumes to form eternal acid rain!"

*Introducing*

NATIONAL GEOGRAPHIC

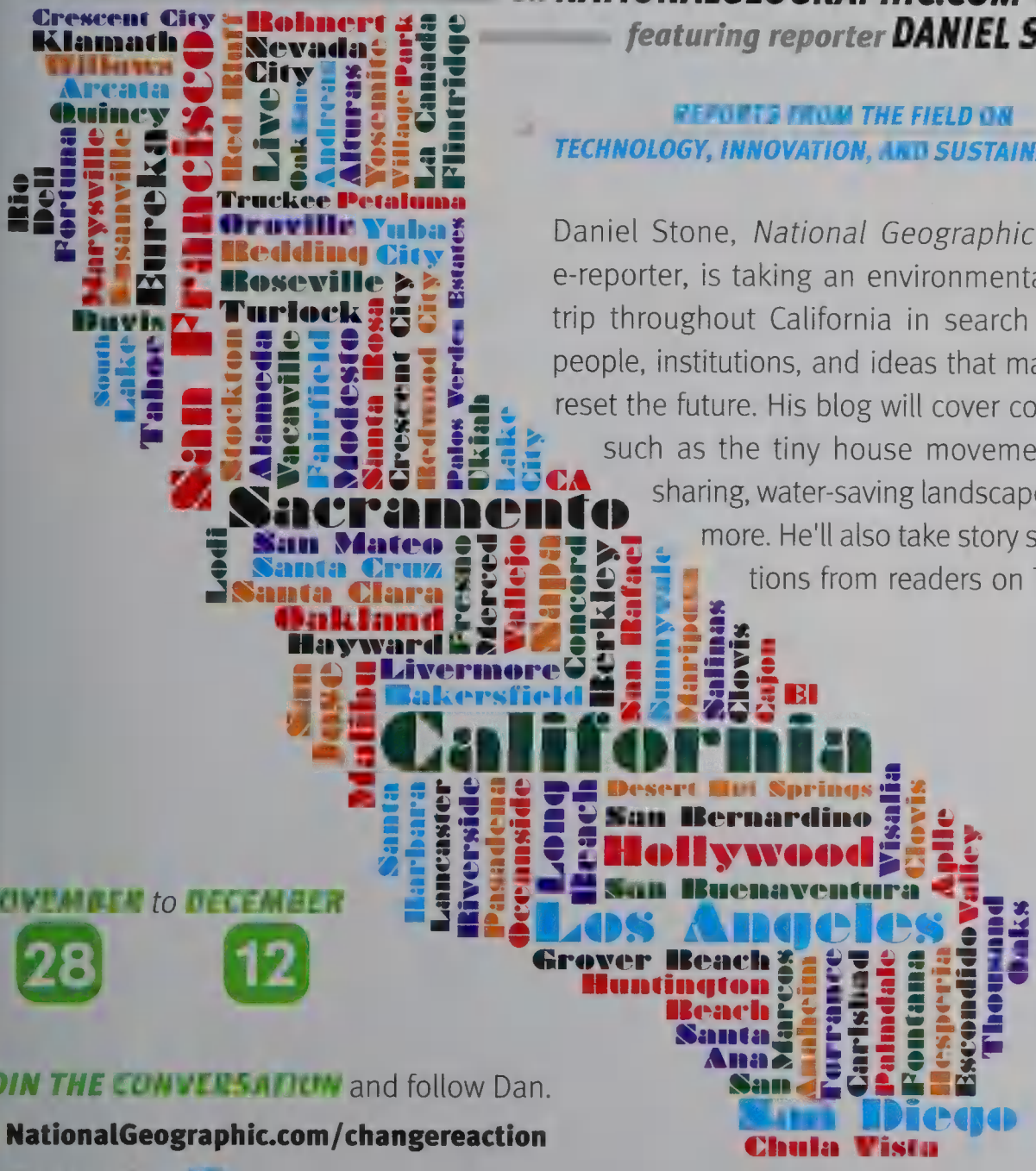
# CHANGE REACTION

on **NATIONALGEOGRAPHIC.COM**

*featuring reporter* **DANIEL STONE**

**REPORTS FROM THE FIELD ON TECHNOLOGY, INNOVATION, AND SUSTAINABILITY**

Daniel Stone, *National Geographic*'s new e-reporter, is taking an environmental road trip throughout California in search of the people, institutions, and ideas that may help reset the future. His blog will cover concepts such as the tiny house movement, car sharing, water-saving landscapes, and more. He'll also take story suggestions from readers on Twitter.

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# NEXT

**SKYCAST**

*Overhead this month in parts of the world*

*December 13–14*
Geminid meteor shower

*December 21–22*
Ursid meteor shower

## Pop Culture

Before they even had pots to cook it in, ancient Peruvians knew the joys of eating popcorn. So says a team of scientists who have found fossilized cobs, husks, stalks, and tassels dating back 6,700 years—ahead of the arrival of ceramics—along the northern coast of Peru. The remains, the oldest ever identified in South America, help put the now ubiquitous crop's chronology in order. According to study co-author Tom Dillehay, the findings place maize in the area 2,000 years earlier than previous discoveries had indicated.

So how did these people pop kernels without cookware? Burned cobs suggest they used heated stones (which were also found with scorch marks). As to consumption practices, Dillehay says popcorn likely wasn't a habitual indulgence but rather signaled a special occasion.

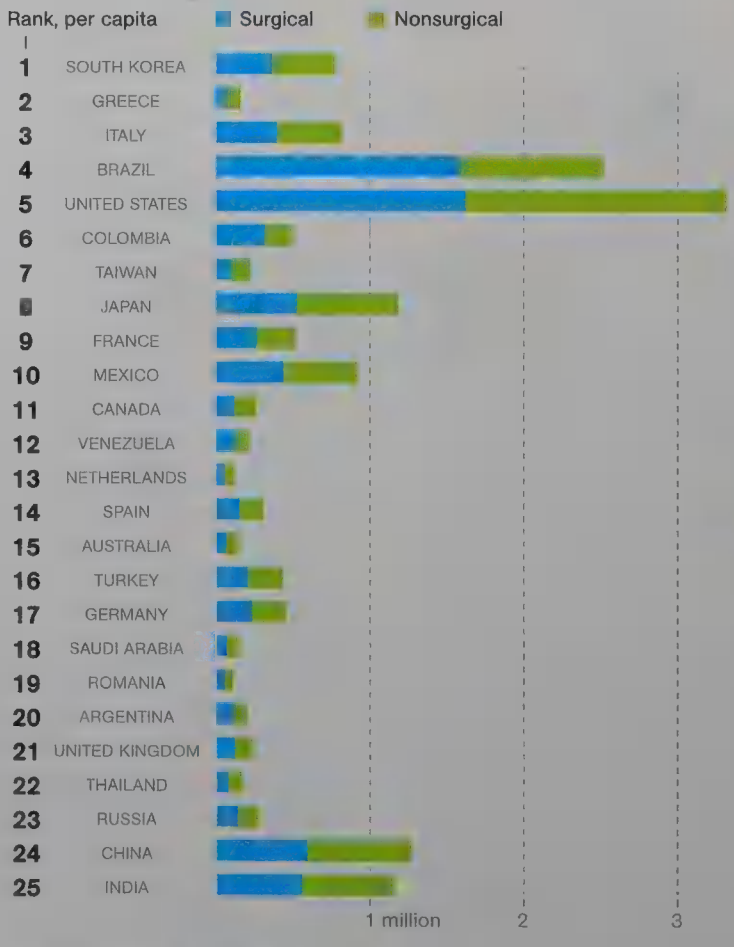
—Amanda Peterman

# Beauty Markets

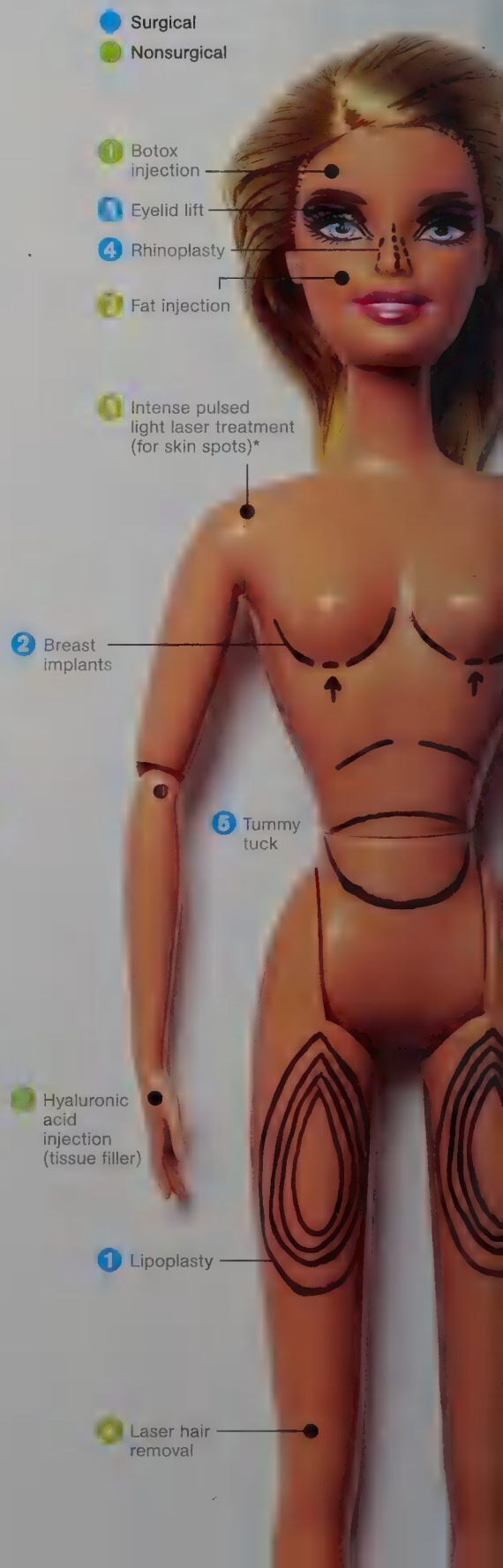
The face of plastic surgery is changing. Once a purely surgical specialty, the field's morphed with the advent of neurotoxins, tissue fillers, and laser treatments over the past 20 years. Patients—mostly women—are now turning more to nonsurgical options for nips and tucks. By one estimate, these make up 82 percent of cosmetic procedures in the U.S.

The quest for beauty is universal, but tastes can vary. Brazilians favor buttock enhancements; Americans tend to seek bigger breast increases than Brazilians, says Renato Saltz, vice president of the International Society of Aesthetic Plastic Surgery. Cultural preferences lead surgery innovations too: facial work in the U.S., rhinoplasty techniques in parts of the Middle East. The U.S. and Brazil top the world in plastic surgeons and procedures, says Saltz, with Asia's numbers expected to rise. *—Luna Shyr*

**Countries with top number of procedures, 2010**




**Top five procedures worldwide, 2010**




*Placement of some procedure labels is approximate.

PHOTO: REBECCA HALE, NGM STAFF. GRAPHIC: LAWSON PARKER, NGM STAFF
SOURCE: INTERNATIONAL SOCIETY OF AESTHETIC PLASTIC SURGERY; MICHAEL OLDING

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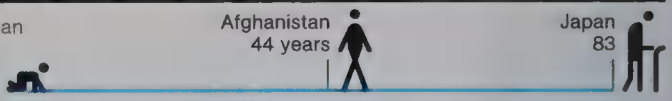
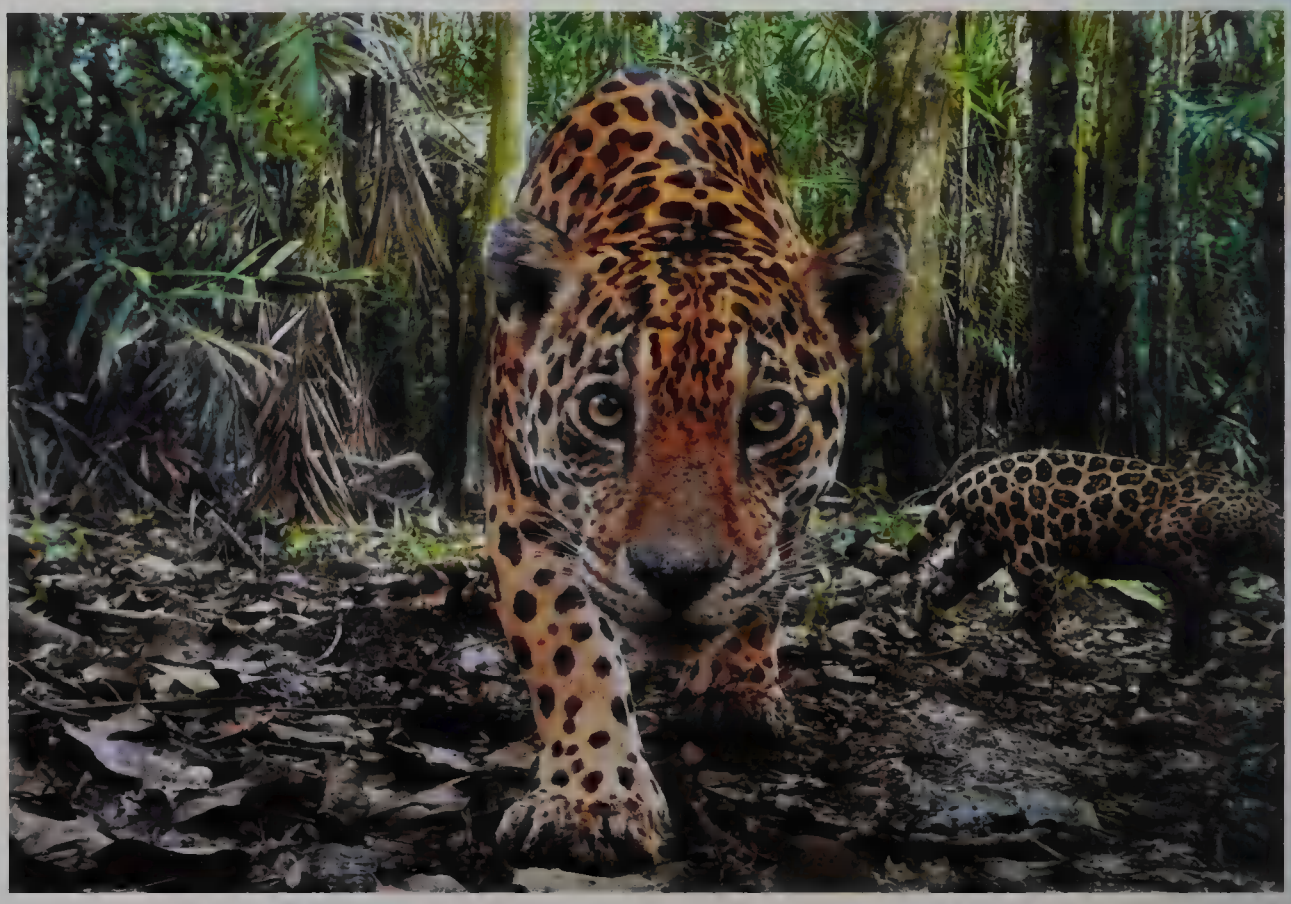
The average life expectancy of a child born in Japan is almost double that of one born in Afghanistan.



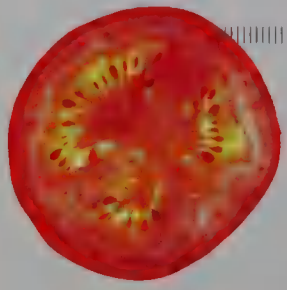



# Jaguar Corridor

Big cats need room to roam. In the case of jaguars that's a stretch from Mexico to Argentina, and human development is getting in their way. Conservationists can usher them across highways with underpasses, but the jaguars balk at crossing the cultivated fields that have replaced their natural cover—especially soy, corn, and oil palm crops in Colombia's Magdalena River Valley. The farms are massive, with no way around besides the prohibitively high Andes.

The first camera-trap photos of a mother and cubs (above) in one sprawling oil palm plantation indicate hope for range preservation for the next generation. Females signal not just quick passage but a stay for reproduction, says Panthera's Howard Quigley. *—Johnna Rizzo*

Get updates on our Big Cats Initiative at **causeanuproar.com.**



## Gene Slice

**Botanists say it's a fruit; the U.S. Supreme Court ruled it a vegetable. One thing's certain: The tomato has about 7,000 more genes than a person. Surprising? Not to the USDA's Jim Giovannoni, who helped lead the newly completed sequencing of the tomato genome. Big genomes allow immobile plants to tolerate genetic changes that can spur new ways of coping with adversity, he explains. Decoding the tomato makes breeding easier—and it revealed a 92 percent genomic match with the potato.** *—Luna Shyr*

PHOTOS: PANTHERA (TOP); JEANNE M. MODDERMAN, NGM STAFF. NGM MAPS. GRAPHIC: ÁLVARO VALIÑO
SOURCE: POPULATION REFERENCE BUREAU

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**FLUID PARKING RATES**
A popular place, like Fisherman's Wharf in San Francisco, can involve parking headaches. To make spots available at peak times, the city is testing variable parking rates. Prime spots and busier periods mean higher prices.

**Weekday, 3 to 7 p.m.**

**$2.75**
Median rate per hour

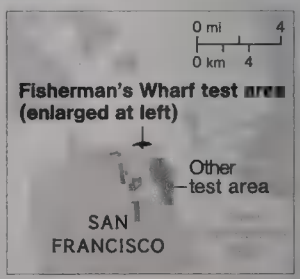
**68%**
Average occupancy

**PARKING RATE** (per hour)

25¢ $1 2 3 4 5

**OCCUPANCY**

0% 50 100



**Weekend, 3 to 7 p.m.**

**$4.25**
Median rate per hour

**91%**
Average occupancy

# Smart Parking

The hunt for street parking in busy cities is enough to drive motorists around the bend. Nonstop circling isn't just a drag for drivers—it's a drag on cities. Donald Shoup, a UCLA professor hailed as the "prophet of parking," estimates that a third of traffic on congested downtown streets involves drivers seeking spots. San Francisco is taking aim with a pilot program that prices parking based on demand.

Sensors in 7,000 of the city's parking spaces provide data for mobile apps that alert drivers when spaces are open. Meanwhile, prices around local hot spots go up at peak times to encourage parking on sleepier streets, where prices go down. Rates are reevaluated every six weeks. Downtown Los Angeles is now following suit; Washington, D.C., and New York City aren't far behind.

The goal is to make parking easier and more convenient. Says Jay Primus, the San Francisco project's leader, "We want people to stop worrying about parking and be free to enjoy themselves." *—Gretchen Parker*

MAPS: LAZARO GAMIO (LEFT). SOURCE: JAY PRIMUS, SAN FRANCISCO MUNICIPAL TRANSPORTATION AGENCY. NGM MAPS

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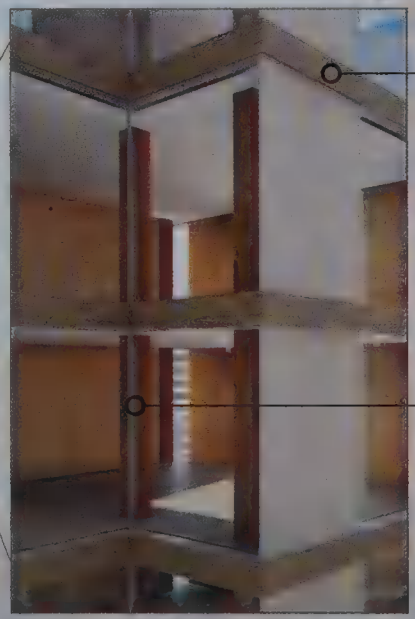
# Hail, Timber

In Nara, Japan, a 122-foot-tall wooden pagoda has stood for more than 1,300 years. Very few modern structures like it exist, largely due to fire-safety concerns and building codes that limit the height of timber structures. Canadian architect Michael Green aims to change that with a proposed wooden skyscraper up to 30 stories high in Vancouver. He explains that giant panels of laminated wood known as mass timber are more fire-resistant than typical two-by-fours, just as logs are harder to ignite than kindling.

The bigger advantage? The production of concrete and steel emits high levels of carbon dioxide, whereas wooden buildings store carbon that would otherwise be released when trees decay or burn. London already has a nine-story mass-timber apartment building, and a 16-story wooden skyscraper is slated for Kirkenes, Norway. Green's ultimate ambition for timber towers is even loftier: provide affordable housing for people living in slums. *—Alex Hoyt*

**Mass Timber**

Instead of traditional lumber, mass timber uses laminated boards and plywood made of sustainably grown lower-grade wood—such as fast-growing birch and aspen—that wouldn't normally be suitable for commercial use.



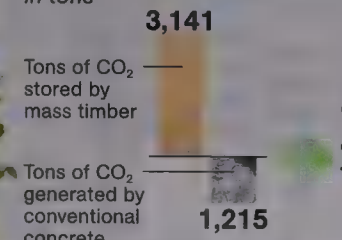
**Laminated Panels**
Based on tree species and regional production, several types of panels can be combined for floors and walls or used alone for a whole building.

**Glulam**
Small-scale lumber glued together creates very strong and fire-resistant beams and columns.

### Carbon Sequestration

Mass timber stores $CO_2$ instead of emitting it, as concrete construction does. The net carbon footprint is negative.

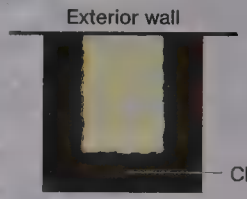
**$CO_2$ impact of ■ 20-story* wood building**
*in tons*




*5,184 SQUARE FEET PER STORY

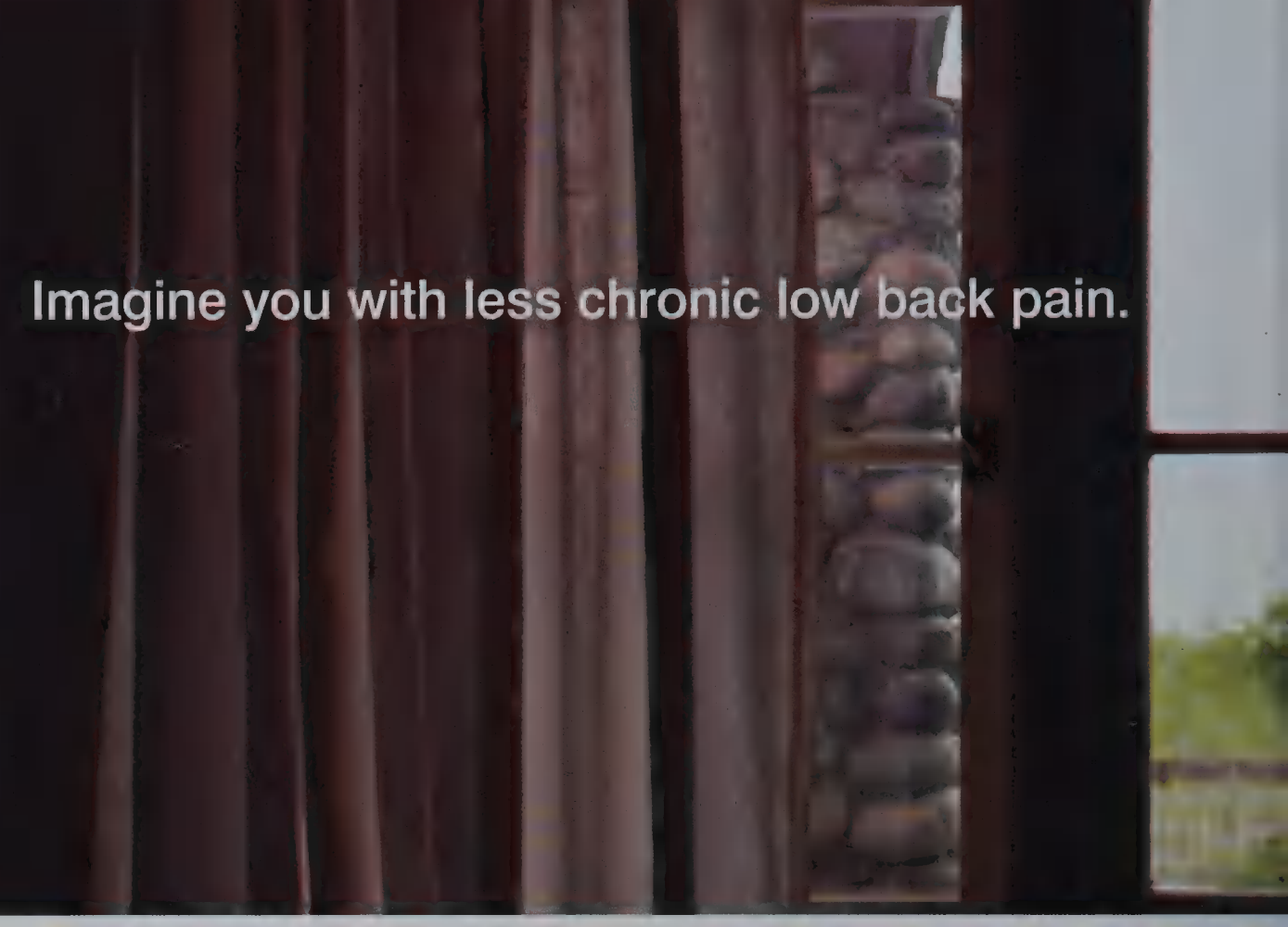
### Fire Protection

Additional layers of wood create a "char layer" that protects structural beams during a blaze. In early tests mass timber withstood fire as well as other building materials.




## Examples of Tall Wooden Structures

JASON TREAT, NGM STAFF. ART: PURE RENDERING GMBH
SOURCE: MICHAEL GREEN AND ERIC KARSH. BUILDING DRAWINGS: LAZARO GAMIO




## Cymbalta can help.

Cymbalta is a once-daily, non-narcotic pain reliever. And it's not addictive.

### When taken once a day, every day, Cymbalta is proven to significantly reduce chronic low back pain.

You may have to rethink the way you treat your pain. You might be used to taking pain medications only after you feel your chronic low back pain getting worse. Managing this pain with Cymbalta is a little different. It's important to take Cymbalta every day, as prescribed by your doctor, to manage your pain over time.

Did you know that your body has a natural pain-suppressing system that can help regulate the amount of pain you feel? Although the exact way that Cymbalta works to reduce chronic low back pain is unknown, it is believed that Cymbalta helps lessen pain by enhancing the body's natural pain-suppressing system by increasing the activity of serotonin and norepinephrine in the brain and spinal cord.

***Visit cymbalta.com or call 1-877-CYMBALTA (1-877-296-2258) to learn more. Ask your doctor about Cymbalta and a free trial offer.***

**Cymbalta is a prescription medication approved for the management of chronic musculoskeletal pain in people with chronic low back pain or chronic osteoarthritis pain.**

## Important Safety Information About Cym

### The most important information you shou know about Cymbalta:

Antidepressants can increase suicidal thought behaviors in children, teens, and young adults. S is a known risk of depression and some other psyc disorders. Call your doctor right away if you have worsening depression symptoms, unusual chan behavior, or thoughts of suicide. Be especially obs within the first few months of treatment or after a c in dose. Approved only for adults 18 and over.

### Cymbalta® (duloxetine HCl) is not for every Do not take Cymbalta if you:

- have recently taken a type of antidepressant call a monoamine oxidase inhibitor (MAOI) or Mellari (thioridazine)
- have uncontrolled narrow-angle glaucoma (increa eye pressure)

### Before taking Cymbalta, talk with your healthcare provider:

- about all your medical conditions, including kidn liver problems, glaucoma, diabetes, seizures, or have bipolar disorder. Cymbalta may worsen a ty glaucoma or diabetes
- about all your prescription and nonprescription me A potentially life-threatening condition has been re when Cymbalta was taken with certain drugs for m mood, or psychotic disorders
- if you are taking NSAID pain relievers, aspirin, or thinners. Use with Cymbalta may increase bleed
- about your alcohol use

Partnership for Prescription Assistance

If you need assistance with prescription costs, help may be available. Visit www.pparx.org or call 1-888-4PPA-NOW.

## nt Safety Information (continued)

your blood pressure. Cymbalta can increase your pressure. Your healthcare provider should check ood pressure prior to and while taking Cymbalta re pregnant or plan to become pregnant during , or are breast-feeding

## aking Cymbalta, talk to your healthcare r right away:

ave itching, right upper-belly pain, dark urine, skin/eyes, or unexplained flu-like symptoms, may be signs of liver problems. Severe liver ms, sometimes fatal, have been reported ave high fever, confusion and stiff muscles, which symptoms of a potentially life-threatening condition ave skin blisters, serious or peeling rash, hives, sores, or any other allergic reaction. These may ous, possibly life-threatening, skin reactions xperience dizziness or fainting upon standing. nds to occur in the first week or when increasing se, but may occur at any time during treatment you stop Cymbalta or change your dose xperience headache, weakness, confusion, ms concentrating, memory problems, or feel dy, which may be signs of low sodium levels evelop problems with urine flow

## mmon side effects of Cymbalta not a complete list):

, dry mouth, sleepiness, fatigue, constipation, ss, decreased appetite, and increased sweating ncouraged to report negative side effects of on drugs to the FDA. Visit www.fda.gov/medwatch 800-FDA-1088.

## Other safety information about Cymbalta:

- Cymbalta may cause sleepiness and dizziness. Until you know how Cymbalta affects you, you should not drive a car or operate hazardous machinery.
- People age 65 and older who took Cymbalta reported more falls, some resulting in serious injuries.

## How to take Cymbalta:

Take Cymbalta exactly as directed by your healthcare provider. Cymbalta should be taken by mouth. Do not open, break or chew capsule; it must be swallowed whole. Cymbalta can be taken with or without food.

Cymbalta is available by prescription only.

DD CON ISI 28NOV2011

**See next page for additional information about Cymbalta, including Boxed Warning about antidepressants and risk of suicide.**

Cymbalta®
duloxetine HCl
20 mg, 30 mg, 60 mg
DELAYED RELEASE CAPSULES

Lilly

# Information For Patients About Cymbalta

Please read this information carefully before you or your family member start taking Cymbalta (sim-BALL-tah), and each time your prescription is refilled, in case anything has changed or new information is available. This information is not meant to take the place of discussions with your healthcare provider. Talk with your healthcare provider or pharmacist if there is something you do not understand or if you want to learn more about Cymbalta. Always follow your healthcare provider's instructions for taking Cymbalta.

## What is the most important information I should know about Cymbalta?

**Warning:** In clinical studies, antidepressants increased the risk of suicidal thinking and behavior in children, adolescents, and young adults with depression and other psychiatric disorders. Anyone considering the use of Cymbalta or any other antidepressant must balance this risk with the clinical need. Short-term studies did not show an increase in the risk of suicidal thinking or behavior with antidepressants in adults older than 24; there was a reduction in risk with antidepressants in adults 65 and older. Suicide is a known risk of depression and some other psychiatric disorders. All patients starting antidepressant therapy should be monitored appropriately and observed closely. Families and caregivers should discuss with the healthcare provider right away any observations of worsening depression symptoms, suicidal thinking and behavior, or unusual changes in behavior. Cymbalta is not approved for use in patients under age 18.

Patients on antidepressants and their families or caregivers should watch for new or worsening depression symptoms, unusual changes in behavior, and thoughts of suicide, as well as for anxiety, agitation, panic attacks, difficulty sleeping, irritability, hostility, aggressiveness, impulsivity, restlessness, or extreme hyperactivity. Call your healthcare provider right away if you have thoughts of suicide or if any of these symptoms is severe or occurs suddenly. Be especially observant within the first few months of treatment or whenever there is a change in dose.

## What is Cymbalta?

Cymbalta is a prescription medicine approved to treat multiple conditions: the treatment of major depressive disorder (MDD), also called depression; generalized anxiety disorder (GAD); the management of fibromyalgia (FM); the management of diabetic peripheral neuropathic pain, also called diabetic nerve pain (DNP); and the management of chronic musculoskeletal pain due to chronic osteoarthritis pain and chronic low back pain.

## Who should NOT take Cymbalta?

You should not take Cymbalta if:

- You are taking a type of antidepressant known as a monoamine oxidase inhibitor (MAOI), such as Nardil® (phenelzine sulfate), Parnate® (tranylcypromine sulfate), or Emsam® (selegiline transdermal system). Using an MAOI with many prescription medicines, including Cymbalta, can cause serious or even life-threatening reactions. You must wait at least 14 days after you have stopped taking an MAOI before you take Cymbalta. You need to wait at least 5 days after you stop taking Cymbalta before you take an MAOI
- You have uncontrolled narrow-angle glaucoma (increased eye pressure)
- You are taking an antipsychotic medicine known as Mellaril® (thioridazine)

## What should I talk to my healthcare provider about before taking Cymbalta?

- About any medical conditions you may have, including kidney or liver problems, glaucoma, diabetes, seizures, or if you have bipolar disorder. Cymbalta may worsen a type of glaucoma or the control of blood sugar in some patients with diabetes
- If you are taking or plan to take any prescription or nonprescription medicines, as Cymbalta may interact with some of these products
- If you take medicines known as triptans, commonly prescribed for migraines or medicines for mood or psychotic disorders. A potentially life-threatening condition may occur if taken with Cymbalta
- If you take NSAID pain relievers, aspirin, or blood thinners. Use with Cymbalta may increase risk of bleeding
- About your alcohol use
- About your blood pressure. Cymbalta can increase your blood pressure. Your healthcare provider should check your blood pressure prior to and while taking Cymbalta
- If you are pregnant, plan to become pregnant, or are breastfeeding. (Lilly has a voluntary registry to collect information about Cymbalta use during pregnancy. To learn more, call 1-866-814-6975 or visit www.cymbaltapregnancyregistry.com)

## What should I talk to my healthcare provider about while taking Cymbalta?

**Call your healthcare provider right away:**

- If you have itching, right upper-belly pain, dark urine, yellow skin/eyes, or unexplained flu-like symptoms, which may be signs of liver problems. Severe liver problems, sometimes fatal, have been reported
- If you have high fever, confusion and stiff muscles, which may be signs of a potentially life-threatening condition
- If you have skin blisters, serious or peeling rash, hives, mouth sores, or any other allergic reaction. These may be serious, possibly life-threatening, skin reactions
- If you experience dizziness or fainting upon standing. This tends to occur in the first week or when increasing the dose, but may occur at any time during treatment, or when used in combination with certain other drugs
- Before stopping Cymbalta or changing your dose. Stopping Cymbalta may result in symptoms including dizziness, nausea, or headache **(not a complete list)**. Your healthcare provider may wish to decrease the dose slowly
- If you experience headache, weakness, confusion, problems concentrating, memory problems, or feel unsteady, which may be signs of low sodium levels
- If you develop problems with urine flow

## What should I avoid while taking Cymbalta?

- Cymbalta may cause sleepiness and dizziness. Until you know how Cymbalta affects you, you should not drive a car or operate hazardous machinery

## What are the most common side effects of Cymbalta?

- In clinical studies for approved indications the most common side effect was nausea
- Other common side effects included dry mou sleepiness, fatigue, constipation, dizziness decreased appetite, and increased sweating

**This is not a complete list of side effec**

See Boxed Warning, "Who should NOT take Cymbalta?" and "What should I talk to my healthcare provider about while taking Cymbalta

See prescribing information at www.cymbalta.co

Talk to your healthcare provider if you have questions or develop any side effects.

**You are encouraged to report negative side effects of prescription drugs to th FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.**

## What else should I know if I'm 65 or older

- People age 65 and older who took Cymba reported more falls, some resulting in seriou injuries

## What should I do if I think I have taken an overdose of Cymbalta?

If you have taken more Cymbalta than prescribed for you, contact your healthcare provider, a hospital emergency room, or the nearest poison control center immediately.

## How should I take Cymbalta?

- Take Cymbalta exactly as directed by your healthcare provider
- Take Cymbalta by mouth. Do not open, break, or chew capsule; swallow it whole
- Cymbalta can be taken with or without foo
- If you miss a dose, take it as soon as you remember. However, if it is time for your nex dose, skip the missed dose and take only yo regularly scheduled dose. Do not take more tha the daily amount of Cymbalta prescribed for yo
- Talk with your healthcare provider before stopping Cymbalta or changing your dose

## General advice about Cymbalta

- Store Cymbalta at room temperature and out of reach of children
- Medicines are sometimes prescribed for purposes other than the ones listed. This medication has been prescribed for your particular condition. Do not use it for anothe condition or give this drug to anyone else
- If you have any questions or concerns, want to report any problems with the use of Cymbalta, or want more information, contac your healthcare provider or pharmacist

Additional information can be found at www.cymbalta.com.

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# PLAN FOR A BETTER WORLD

In 2007, Pat Minnick decided to establish a charitable gift annuity to support National Geographic. She now receives a guaranteed life income and is a direct part of the Society's efforts to inspire people to care about the planet. She says, "I feel good knowing that National Geographic is doing so much to protect endangered wildlife."

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**Two if by Sea** Explorers-in-Residence Enric Sala and Mike Fay are tag teaming in the name of the unprotected oceans. Sala dives and documents, while naturalist Fay walks islands and atolls to assess connections between locals on land and the surrounding seas. The combined data help the duo propose sanctuaries sustainable for people and ocean life under the Pristine Seas project.

In 2012, Pristine Seas and partner Pew Environment Group started a process of protecting the 200 miles around the Pitcairn Islands. At up to 320,000 square miles, it would be one of the world's largest marine reserves, include at least eight new species of fish, and maybe change the way oceans are understood. "Most studies focus on wrecked seas," Sala says. "Places like the Pitcairns show us how oceans can be." *—Johnna Rizzo*

*Middle-size predators like the yellow-edged lyretail prowl Oeno Island in the Pitcairns.*

**IN LETTERS**

The discovery of a 62-mile **PHYTOPLANKTON BLOOM** beneath Arctic ice surprised scientists who thought sea ice limited the growth of microscopic marine plants. ▪ The largest **3-D MAP OF THE UNIVERSE,** created by the Sloan Digital Sky Survey III, includes galaxies up to six billion light-years from Earth. ▪ **GIRAFFE SPOTS** reveal clues about the animal's age, darkening around puberty, a study found. ▪ A rare copy of a 1507 Martin Waldseemüller world map known as **AMERICA'S BIRTH CERTIFICATE** turned up in Munich.

PHOTO: ENRIC SALA. NGM MAPS

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For each surname in the U.S. there are 350 people on average.
In China there are 174,696.

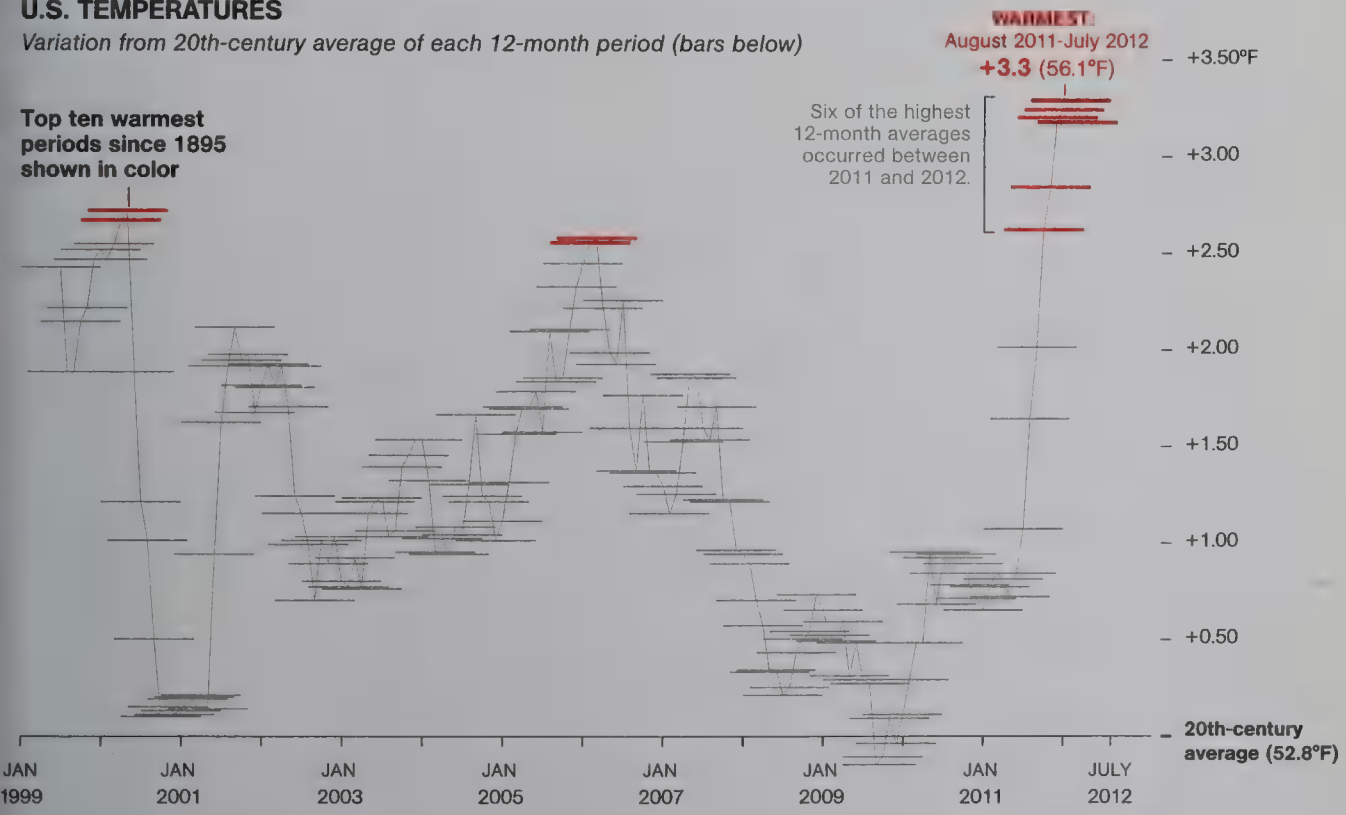
# Mercury Rising

This past summer capped the hottest 12-month period on the books in the mainland United States. According to the National Climatic Data Center, it was also part of an unprecedented 15-month stretch (ugust) of above-average temperatures gan in June 2011, surpassing even the scorching Dust Bowl days of the 1930s.

Last year's abnormally mild winter was one reason for the spate of records. Another was a brutal July 2012, which set a new mark as the hottest month (77.6°F average) since record-keeping began in 1895. Don't bet on the trend ending anytime soon: NOAA scientists predict the northern U.S. will remain warmer than usual into 2013. *—Erin Friar McDermott*

**U.S. TEMPERATURES**

*Variation from 20th-century average of each 12-month period (bars below)*



## Saving Soap Saves Lives

Where does all that partially used hotel soap and shampoo go after guests leave? Traditionally it went in the trash, but now millions of bars and bottles go to Clean the World, a nonprofit that recycles and redistributes the products globally. The goal: to fend off pneumonia and diarrheal diseases. The leftover bars are melted and sterilized, then pressed into new, fresh cakes. More than 1,600 North American hotels participate in the program, which includes delivery to poor communities—with a side of education. Kids are taught to sing songs, including a Spanish one with the refrain "Wash your hands, healthy children. Wash your hands." *—Catherine Zuckerman*

GRAPHICS: ÁLVARO VALIÑO. SOURCES: YAN LIU, "A STUDY OF SURNAMES IN CHINA THROUGH ISONYMY"; U.S. CENSUS BUREAU (SURNAMES); NOAA (CHART). PHOTO: MIKE KEMP, RUBBERBALL/GETTY IMAGES

# Forest Giant

A tree-climbing scientist and his team have learned surprising new facts about giant sequoias by measuring them inch by inch.

Giant sequoias live at high elevations, enduring cold, heavy snows, lightning strikes—and growing bulky and strong. Though not as tall as coast redwoods, this individual, the President, is the second most massive tree known on Earth.

The living crown (this one atop the General Sherman, at center) was once a distant mystery. Scientist Steve Sillett's new arboreal studies have yielded revelations, including this: These old trees are still growing fast.

*By David Quammen*

*Photographs by Michael Nichols*

On a gentle slope above a trail junction in Sequoia National Park, about 7,000 feet above sea level in the southern Sierra Nevada, looms a very big tree. Its trunk is rusty red, thickened with deep layers of furrowed bark, and 27 feet in diameter at the base. Its footprint would cover your dining room. Trying to glimpse its tippy top, or craning to see the shape of its crown, could give you a sore neck. That is, this tree is so big you can scarcely look at it all. It has a name, the President, bestowed about 90 years ago by admiring humans. It's a giant sequoia, a member of *Sequoiadendron giganteum,* one of several surviving species of redwoods.

It's not quite the largest tree on Earth. It's the second largest. Recent research by scientist Steve Sillett of Humboldt State University and his colleagues has confirmed that the President ranks number two among all big trees that have ever been measured—and Sillett's team has measured quite a few. It doesn't stand so tall as the tallest of coast redwoods or of *Eucalyptus regnans* in Australia, but height isn't everything; it's far more massive than any coast redwood or eucalypt. Its dead spire, blasted by lightning, rises to 247 feet. Its four great limbs, each as big as a sizable tree, elbow outward from the trunk around halfway up, billowing into a thick crown like a mushroom cloud flattening against the sky. Although its trunk isn't quite so bulky as that of the largest giant, the General Sherman, its crown is fuller than the Sherman's. The President holds nearly two billion leaves.

Trees grow tall and wide-crowned as a measure of competition with other trees, racing upward, reaching outward for sunlight and water. And a tree doesn't stop getting larger—as a terrestrial mammal does, or a bird, their size constrained by gravity—once it's sexually mature. A tree too is constrained by gravity, but not in the same way as a condor or a giraffe. It doesn't need to locomote, and it fortifies its structure by continually adding more wood. Given the constant imperative of seeking resources from the sky and the soil, and with sufficient time,

*David Quammen's new book,* Spillover, *is about zoonotic diseases. Michael Nichols photographed California's giant redwoods for the October 2009 issue.*

**The giant sequoia is a snow tree, Sillett says, adapted for long winters in the Sierra. But it's a fire tree too. Thick bark protects it from burning in lightning-caused fires, which open cones and clear the understory, allowing saplings to find light and prosper.**

a tree can become huge and then keep growing. Giant sequoias are gigantic because they are very, very old.

They are so old because they have survived all the threats that could have killed them. They're too strong to be knocked over by wind. Their heartwood and bark are infused with tannic acids and other chemicals that protect against fungal rot. Wood-boring beetles hardly faze them. Their thick bark is flame resistant. Ground fires, in fact, are good for sequoia populations, burning away competitors, opening sequoia cones, allowing sequoia seedlings to get started amid the sunlight and nurturing ash. Lightning hurts the big adults but usually doesn't kill them. So they grow older and bigger across the millennia.

Another factor that can end the lives of big trees, of course, is logging. Many giant sequoias fell to the ax during the late 19th and early 20th centuries. But the wood of the old giants was so brittle that trunks often shattered when they hit the ground, and what remained had little value as lumber. It went into shingles, fence posts, grape stakes, and other scrappy products. Given the difficulties of dealing with logs 20 feet thick,

Download our iPad and Kindle Fire editions to watch a video about how these giants were photographed by Michael Nichols and his team.

## THE PRESIDENT

*Sequoiadendron giganteum*

HEIGHT: 247 feet
AGE: at least 3,200 years
DIAMETER AT BASE: 27 feet
TOTAL VOLUME: 54,000 cubic feet

**LIMBS** The four largest limbs range in diameter from five to nearly seven feet; the largest is about 60 feet long. The tree's total number of branches: 534.

**FOLIAGE** The scientists who measured every part of the tree estimate it has nearly two billion leaves and more than 82,000 cones. Each cone, the size of a chicken's egg, holds about 200 seeds.

**SHAPE** The President reached its current height well over a thousand years ago but continues to expand in volume of wood, its crown growing more intricate.

**SCARS** Fire damage extends 50 feet up one side of the trunk. The top 40 feet of the main trunk, struck by lightning, has been dead for more than a thousand years.

**GROVES** Sequoias rarely grow in pure stands, but by sheer size they dominate their groves, which hold a variety of tree species.

MARTIN GAMACHE AND MATTHEW TWOMBLY, NGM STAFF
ART: ROBERT VAN PELT, HUMBOLDT STATE UNIVERSITY (HSU)

SOURCES: STEVE SILLETT, HSU; BLM; NATIONAL PARK SERVICE; USGS; BILL KRUSE, KRUSE IMAGING; DWIGHT WILLARD; SIERRA NEVADA ECOSYSTEM PROJECT; D'ARCY TRASK, CYARK

# Where the Giants Grow

A slender, 250-mile-long corridor on the western slope of the Sierra Nevada is the giant sequoia's only natural habitat. No tree surpasses it in volume of wood. Fortunately, logging proved impractical, and in 1890 many of the titans gained protection with the creation of Sequoia and Yosemite National Parks.

Placer County Grove

**NORTHERN LIMIT**
Only six giant sequoias form this isolated old-growth grove.

Lake Tahoe

Reno

39°

CALAVERAS BIG TREES STATE PARK

**SEQUOIA MYSTERY**
Scientists remain uncertain why the northern stretch of the range supports only a few scattered groves.

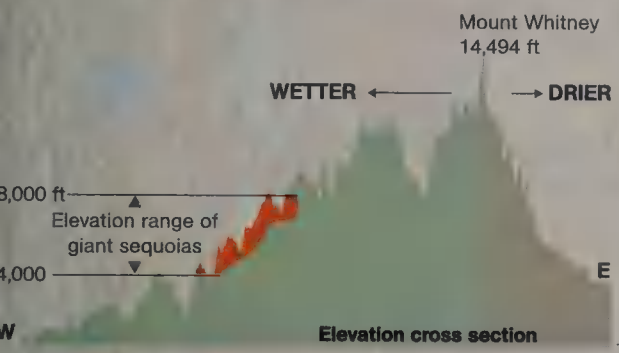
SIERRA NEVADA

NEVADA CALIFORNIA

YOSEMITE NATIONAL PARK

Mono Lake

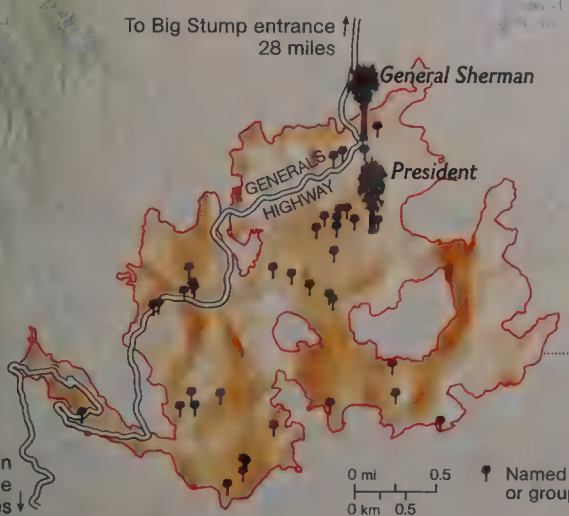
38°




**SEQUOIA SWEET SPOT** Conditions that suit the tree's growth and reproduction exist in a narrow elevation range. The Sierra's eastern slope is too dry for sequoias, which need rain and the deep moisture of heavy snowmelt.

**GROVE DISTRIBUTION**
All but 8 of the 67 identified sequoia groves lie south of the Kings River. These southern groves usually hold more—and larger—trees.

Bishop




**CATHEDRAL OF TREES** The Giant Forest, a grove in Sequoia National Park, protects 41 named sequoias and sequoia groups, including the President and, measuring only slightly bigger, Earth's most massive tree, the General Sherman.

Kings

KINGS CANYON NATIONAL PARK

W Elevation cross section E

Giant Forest

Mount Whitney
14,494 ft
4,418 m

SEQUOIA NATIONAL PARK

Giant sequoia grove

0 mi 10
0 km 10
N

TULE RIVER INDIAN RESERVATION

37°

119°

36°

118°

Before it was felled in the early 1900s, this giant in Converse Basin provided a backdrop for hundreds posing for photographs. The difficulties of logging saved giant sequoias in other groves from this fate.

COURTESY NATIONAL PARK SERVICE

broken or unbroken, the trees were hardly worth cutting. Sequoia National Park was established in 1890, and automobile tourism soon showed that giant sequoias were worth more alive.

One thing to remember about them, as Steve Sillett explained to me during a conversation amid the trees, is that they withstand months of frigid conditions. Their preferred habitat is severely wintry, so they must be strong while frozen. Snow piles up around them; it weights their limbs while the temperature wobbles in the teens. They handle the weight and the cold with aplomb, as they handle so much else. "They're a snow tree," he said. "That's their thing."

Among the striking discoveries made by Sillett's team is that even the rate of growth of a big tree, not just its height or total volume, can increase during old age. An elderly monster like the President actually lays down more new wood per year than a robust young tree. It puts that wood around the trunk, which grows wider, and into the limbs and the branches, which grow thicker.

This finding contradicts a long-held premise in forest ecology—that wood production decreases during the old age of a tree. That premise, which has justified countless management decisions in favor of short-rotation forestry, may hold true for some kinds of trees in some places, but not for giant sequoias (or other tall species, including coast redwoods). Sillett and his team have disproved it by doing something that earlier forest ecologists didn't: climbing the big trees—climbing all over them—and measuring them inch by inch.

With blessings and permits from the National Park Service, they performed such high-altitude metrics on the President. This was part of a larger study, a long-term monitoring project on giant sequoias and coast redwoods called the Redwoods and Climate Change Initiative. Sillett's group put a line over the President's crown, rigged climbing ropes into position (with special protectors for the tree's cambium), donned harnesses and helmets, and went up. They measured the trunk at different heights; they measured limbs, branches, and burls; they counted cones; they took core samples using a sterilized borer. Then they fed the numbers through mathematical models informed by additional data from other giant sequoias. That's how they came to know that the President contains at least 54,000 cubic feet of wood and bark. And that's how they detected that the old beast, at about the age of 3,200, is still growing quickly. It's still inhaling great breaths of $CO_2$ and binding the carbon into cellulose, hemicellulose, and lignin in a growing season interrupted by six months of cold and snow. Not bad for an oldster.

That's the remarkable thing about them, Sillett told me. "Half the year, they're not growing aboveground. They're in the snow." They grow bigger than their biggest compeer, the coast redwood, even with a shorter growing season.

It was fitting, therefore, that Michael (Nick) Nichols made his portrait of the President in snow. Nick and Jim Campbell Spickler, an expert climber and rigger, came up with a plan. With a crew of assistants and climbers drawn heavily from Steve Sillett's team, they arrived in mid-February, when the snowbanks along the plowed road were 12 feet high. They rigged ropes on the President and on a tall nearby tree, both for human ascent and for raising cameras. They waited through blue skies, slushy conditions, and fog until the weather changed and the snow came again and the moment was right. They got the shot. (Actually there were many individual shots, assembled as you see on the poster.) By the time I showed up, they were packing to leave.

Nick had spent more than two weeks commanding this operation, composing the image and engineering it from the ground. But before the last ropes came down, he wanted to climb the tree himself. Not to take photos, he explained. "Just to say goodbye." He put on a harness and a helmet, clipped onto a rope, fit his feet into the loops, clutched the ascender, and up he went.

**Society Grant** This project was funded in part by your National Geographic Society membership.

We thank Sequoia National Park for its generous cooperation in the production of this article.

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Cloaked in the snows of California's Sierra Nevada, the 3,200-year-old giant sequoia called the President rises 247 feet. Two other sequoias have wider trunks, but none has a larger crown, say the scientists who climbed it. The figure at top seems taller than the other climbers because he's standing forward on one of the great limbs.

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SPECIES WERE PHOTOGRAPHED AT THE PRESIDENT TREE IN SEQUOIA NATIONAL PARK AND AT THE UNIVERSITY OF CALIFORNIA, BERKELEY'S WHITAKER FOREST RESEARCH STATION AND SAGEHEN CREEK FIELD STATION. FIND A COMPLETE LIST OF SPECIES NAMES ON OUR IPAD AND KINDLE FIRE EDITIONS AND AT *NGM.COM*. SPECIES NOT SHOWN TO SCALE.

# Tree of Life

*Photographs by David Liittschwager*

A giant sequoia is an ecosystem unto itself. The species here represent just a sample of the living things that call the tree home. Most are insects—from beetles to butterflies to wasps. Some are familiar, like the young robin and the lodgepole chipmunk. All make good use of the sequoia's offerings. Bats roost in the foliage and under loose bark. Ample shade nurtures plants like the pink pygmy rose and the wildflower called little prince's pine, with its pealike center. The Columbian emerald moth and the northern flying squirrel prefer the heights of the crown.

**Resolute and anchored in their remote habitat, the giant sequoias withstand the weight of winter snow and many other stresses. They have seen times and trends and peoples come and go; we are merely the latest.**

Once Nick was down, I went up myself—slowly, clumsily, with help from Spickler. Ascending, I braced my feet gratefully against the great trunk. I stood for a moment, with Spickler beside me, on one of the huge limbs. After half an hour, I found myself in the crown of the President, 200 feet above the ground. I saw the big burls at close range. I saw the smooth, purplish bark of the smaller branches. All around me was living tree. I looked up, dizzily, noticing small cracks in the deadwood and channels of cambium that flowed between trunk and limbs like a river of life. I thought: What an amazing place. Then I thought: What an amazing creature.

Next afternoon, with Nick and the others gone, I snowshoed back to the President alone. There had been too much to take in, and I wanted another look. For a while I gaped at the tree. It was magnificent. Serene. It didn't sway in the breeze; too solid to sway. I wondered about its history. I contemplated its durability and its patience. The day was warmish, and as I stood there, the President released a small dollop of melting snow from a high branch. The snow scattered as it fell, dissipating into tiny flecks and crystals, catching the light as they tumbled toward me.

"Gesundheit," I said. □

BY JAMES VERINI
PHOTOGRAPHS BY PAOLO PELLEGRIN

# THE TUNNELS OF GAZA

**ARE A LIFELINE OF THE UNDERGROUND ECONOMY BUT ALSO A DEATH TRAP. FOR MANY PALESTINIANS, THEY HAVE COME TO SYMBOLIZE INGENUITY AND THE DREAM OF MOBILITY.**

A worker emerges from one of hundreds of smuggling tunnels that connect the Gaza Strip and Egypt.

**FOR AS LONG AS THEY WORKED IN THE SMUGGLING TUNNELS BENEATH THE GAZA STRIP, SAMIR AND HIS BROTHER YUSSEF SUSPECTED THEY MIGHT ONE DAY DIE IN THEM.**

When Yussef did die, on a cold night in 2011, his end came much as they'd imagined it might, under a crushing hail of earth.

It was about 9 p.m., and the brothers were on a night shift doing maintenance on the tunnel, which, like many of its kind—and there are hundreds stretching between Gaza and Egypt's Sinai Peninsula—was lethally shoddy in its construction. Nearly a hundred feet below Rafah, Gaza's southernmost city, Samir was working close to the entrance, while Yussef and two co-workers, Kareem and Khamis, were near the middle of the tunnel. They were trying to wedge a piece of plywood into the wall to shore it up when it began collapsing. Kareem pulled Khamis out of the way, as Yussef leaped in the other direction. For a moment the surge of soil and rocks stopped, and seeing that his friends were safe, Yussef yelled out to them, *"Alhamdulillah!*—Thank Allah!"

Then the tunnel gave way again, and Yussef disappeared.

Samir heard the crashing sounds over the radio system. He took off into the tunnel, running at first and then, as the opening got narrower and lower, crawling. He had to fight not to faint as the air became clouded with dust. It was nearly pitch black when he finally found Kareem and Khamis digging furiously with their hands. So Samir started digging. The tunnel began collapsing again. A concrete-block pillar slashed Kareem's arm. "We didn't know what to do. We felt helpless," Samir told me.

After three hours of digging, they uncovered a blue tracksuit pant leg. "We tried to keep Samir from seeing Yussef, but he refused to turn away," Khamis told me. Screaming and crying, Samir frantically tore the rocks off his brother. "I was moving but unconscious," he said. Yussef's chest was swollen, his head fractured and bruised. Blood streamed from his nose and mouth. They dragged him to the entrance shaft on the Gazan side, strapped his limp body into a harness, and workers at the surface pulled him up. There wasn't room for Samir in the car that sped his brother to Rafah's only hospital, so he raced behind on a bicycle. "I knew my brother was dead," he said.

I WAS SITTING WITH Samir, 26, in what passed for Yussef's funeral parlor, an unfinished-concrete room on the ground floor of the apartment block in the Jabalia refugee camp where the brothers grew up. Outside, in a trash-strewn alley, was a canvas tent that shaded the many mourners who had come to pay their respects over the previous three days. The setting was a typical Gazan tableau: concrete-block walls

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*Correspondent James Verini is based in Nairobi, Kenya. This is his first story for the magazine. Frequent contributor Paolo Pellegrin lives in Rome.*



NGM MAPS

**A NEW TUNNEL OWNER,** in white cap, watches his son descend into the well shaft to continue digging. Wealthy owners can afford mechanized winches, but this man, who saved for years to get a share of the tunnel trade, must rely on his family and a horse.

pocked by gunfire and shrapnel from Israeli incursions and the bloodletting of local factions, children digging in the dirt with kitchen spoons, hand-cranked generators thrumming—yet another Gaza power outage—their diesel exhaust filling the air.

"I was so scared," Samir said, referring to the day in 2008 when he joined Yussef to work in the tunnels. "I didn't want to, but I had no choice." Thin, dressed in sweatpants, a brown sweater, dark socks, and open-toe sandals, Samir was nervous and fidgety. Like the others in the room, he was chain-smoking. "You can die at any moment," he said. Some of the tunnels Yussef and Samir worked in were properly maintained—well built, ventilated—but many more were not. Tunnel collapses are frequent, as are explosions, air strikes, and fires. "We call it *tariq al shahada ao tariq al mawt,*" Samir said—"a way to paradise or a way to death."

Everybody, it seemed, had injuries or health problems. Yussef had developed a chronic respiratory illness. Khamis's leg had been broken in a collapse. Their co-worker Suhail pulled up his shirt to show me an inches-long scar along his spine, a permanent reminder of the low ceilings. "In Rafah," Samir said, "it felt like a bad omen was present all the time. We always expected something bad to happen."

In the Gaza Strip today hero status is no longer reserved for the likes of Yasser Arafat and Ahmed Yassin—the late leaders, respectively,

**LAMB IS A LUXURY** most Gazans can afford only on important Muslim holidays. With many farms devastated by war, and with other land lying unproductive in areas restricted by Israel, livestock comes in by tunnel from Egypt.

**THIS GAZAN UNIVERSITY STUDENT** works in a tunnel, hauling goods to earn money for tuition. Many workers put in 12-hour shifts six days a week—or more—in the cramped spaces. Gas explosions, electrocutions, and Israeli air strikes are common.

of Fatah and the Islamic Resistance Movement, better known as Hamas—or for Palestinians who've died in the fighting that has rocked this wisp of land since its creation 63 years ago. Now tunnel victims like Yussef—28 when he died—are also honored.

"Everybody loved him," Samir said. He was "so kindhearted." On the walls of the makeshift funeral parlor hung posters with Koranic verses of sympathy sent by the family that ran the grade school where Yussef had studied, by the imam of his mosque, and by the local functionaries of Gaza's bitter political rivals: Fatah, the former ruling party, and Hamas, the militant group that now governs the strip. The most prominent poster was from the local mukhtar, a traditional Arab leader. It showed Yussef in a photograph taken five months earlier, on his wedding day. He was wearing a white dress shirt and a pink tie. He had short-cropped hair and eager, gentle eyes. The poster read, "The sons of the mukhtar share condolences with the family in the martyrdom of the hero Yussef."

The Rafah underground isn't new—there have been smuggling tunnels here since 1982, when the city was split following the 1979 Egypt-Israel Peace Treaty, which left part of it in Gaza and part in Egypt. Back then the tunnel well shafts were dug in home basements. The Israeli military, knowing that the tunnels were used for arms trafficking, began demolishing homes that harbored tunnels, as did some Palestinians who

**BOXES OF COOKING OIL** from Egypt—an essential item in Gazan homes—are stacked at the covered entrance to a tunnel in Rafah. Construction materials such as cement, steel bars, and gravel make up the greatest volume of tunnel imports.

wanted to keep the tunnel economy under their control. When that didn't end the smuggling, Israel later expanded the demolitions, creating a buffer zone between the border and the city. According to Human Rights Watch, some 1,700 homes were destroyed from 2000 to 2004.

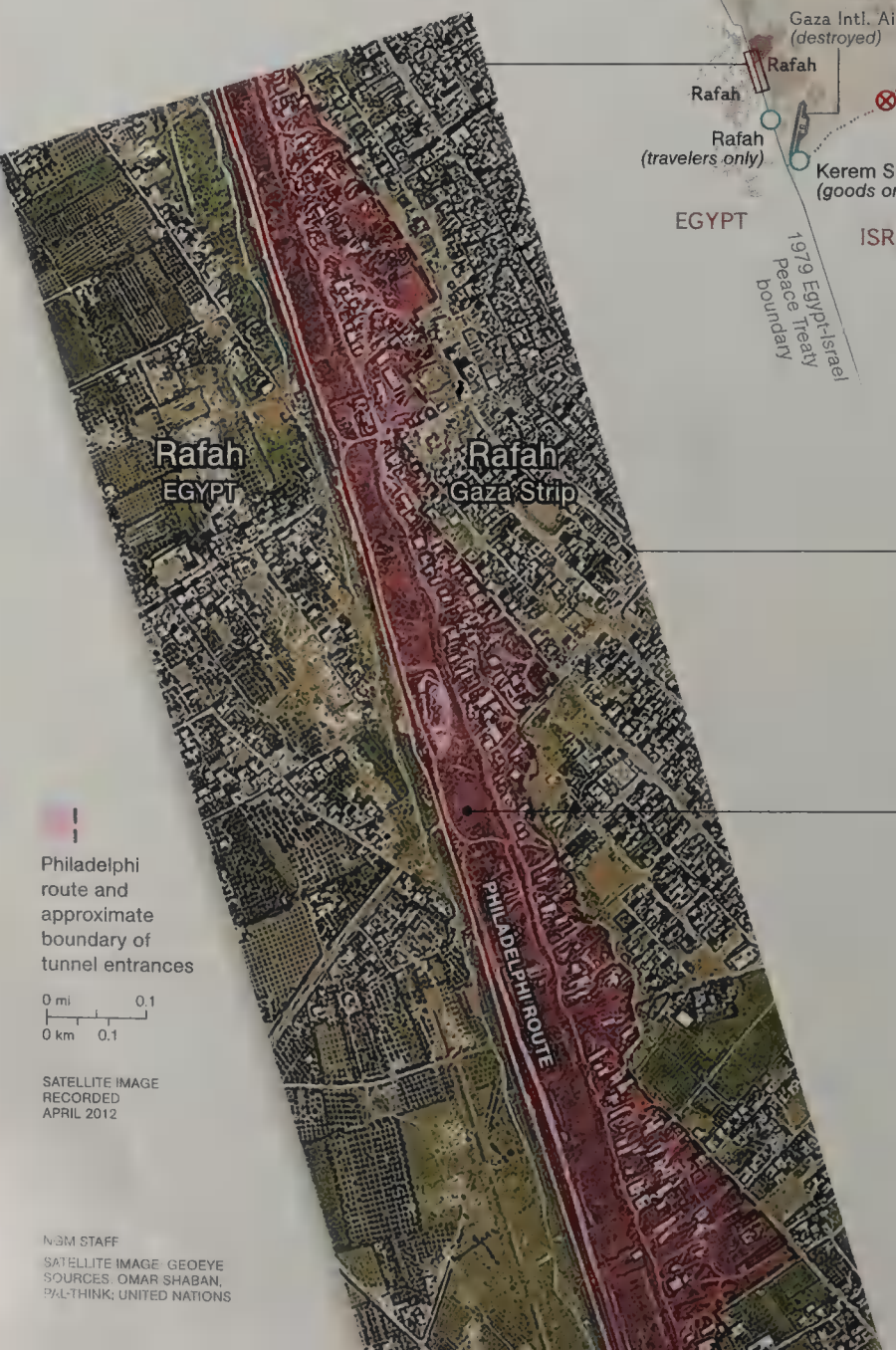
Gaza's tunnels became imprinted on the Israeli public consciousness in 2006, when a group of Hamas-affiliated militants emerged in Israel near a border crossing and abducted Cpl. Gilad Shalit. Shalit became the embodiment of a ceaseless war, his face staring out from roadside billboards much like the faces on martyrdom posters that adorn the walls in Jabalia and the other camps. (He was finally released in a prisoner exchange in the fall of 2011.)

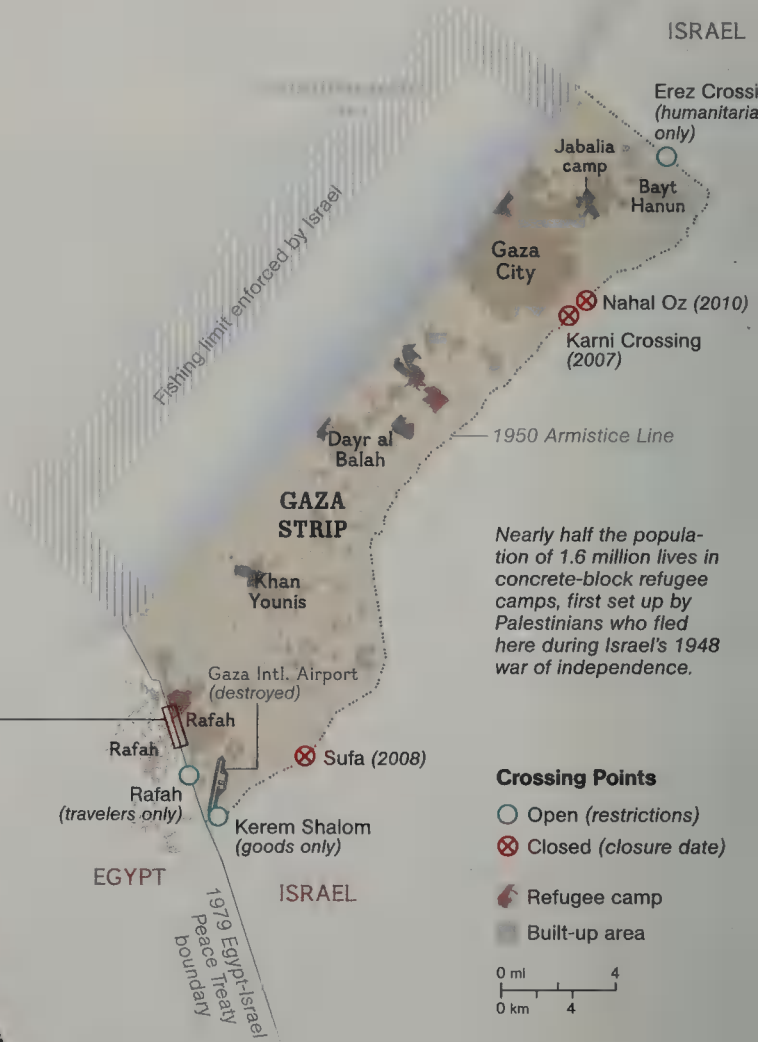
After Hamas won elections in 2006, it and Fatah fought a vicious civil war—which Hamas won the next year, taking control of the Gaza Strip—and Israel introduced an incrementally tightening economic blockade. It closed ports of entry and banned the importation of nearly everything that would have allowed Gazans to live above a subsistence level. Egypt cooperated.

Since Hosni Mubarak's departure in early 2011, Egyptian officials have expressed remorse for cooperating with Israel. Egypt has reopened the small Rafah border crossing, though it still prevents some Gazans from coming through. Its new president, Mohamed Morsi, who wants to keep Hamas at a distance, has not pledged to help Gaza in a way that many Gazans had hoped

# GAZA IN BETWEEN

A satellite image of the divided city of Rafah shows the corridor, shaded pink, where white tents mark entrances to some of the hundreds of smuggling tunnels. Two-thirds of goods entering Gaza come from Egypt via the tunnels. Israeli imports come by truck through the Kerem Shalom crossing (map). Because of attacks by Palestinian militants, Israel has blockaded its border as well as Gaza's airspace and 25-mile-long coast since 2007.




*Nearly half the population of 1.6 million lives in concrete-block refugee camps, first set up by Palestinians who fled here during Israel's 1948 war of independence.*

**Rafah** was split between Egypt and Gaza in 1982, per the 1979 Egypt-Israel Peace Treaty. Israel continued to control Gaza but in 1993 agreed to Gaza's transition to autonomy, withdrawing in 2005.

**The Philadelphi route** was created as a linear military buffer by the 1979 treaty. In adjacent areas in Rafah, Israel later bulldozed some 1,700 homes suspected of hiding tunnels used to smuggle weapons.

**The tunnel economy** accelerated as Israel tightened its border blockade. Concerned about militants, Egypt too restricts movement of goods and people and has destroyed some tunnel entrances.

Philadelphi route and approximate boundary of tunnel entrances

0 mi 0.1
0 km 0.1

SATELLITE IMAGE RECORDED APRIL 2012

NGM STAFF

SATELLITE IMAGE: GEOEYE
SOURCES: OMAR SHABAN, PALTHINK; UNITED NATIONS

he would. In August, after a group of 16 Egyptian soldiers were killed by gunmen in northern Sinai, Egypt temporarily shut down the Rafah crossing and demolished at least 35 tunnels.

After Israel introduced the blockade, smuggling became Gaza's alternative. Through the tunnels under Rafah came everything from building materials and food to medicine and clothing, from fuel and computers to livestock and cars. Hamas smuggled in weapons. New tunnels were dug by the day—by the hour, it seemed—and new fortunes minted. Families sold their possessions to buy in. Some 15,000 people worked in and around the tunnels at their peak, and they provided ancillary work for tens of thousands more, from engineers and truck drivers to shopkeepers. Today Gaza's underground economy accounts for two-thirds of consumer goods, and the tunnels are so common that Rafah features them in official brochures.

"We did not choose to use the tunnels," a government engineer told me. "But it was too hard for us to stand still during the siege and expect war and poverty." For many Gazans, the tunnels, lethal though they can be, symbolize better things: their native ingenuity, the memory and dream of mobility, and perhaps most significant for a population defined by dispossession, a sense of control over the land. The irony that control must be won by going beneath the land is not lost on Gazans.

THE REGION OF GAZA has been fought over—and burrowed under—since long before Israel assumed control of it from Egypt in 1967. In 1457 B.C. Pharaoh Thutmose III overran Gaza while quashing a Canaanite rebellion. He then held a banquet, which he enjoyed so much that he ordered chiseled into the Temple of Amun at Karnak: "Gaza was a flourishing and enchanting city." Thutmose was followed by Hebrews, Philistines, Persians, Alexander the Great (whose siege of Gaza City required digging beneath its walls), Romans, Byzantines, Arabs, Tatars, Mamluks, and Ottomans. Then came Napoleon, the British, Egyptians again, and Israelis, though to this day there is disagreement about whether Gaza would have been considered part of the land the Bible says God promised the Jews. This is partly why expansionist-minded Israelis have focused more intensely on the West Bank than on Gaza; the last Israeli settlement in Gaza was vacated in 2005.

But Gaza is the heart of Palestinian resistance. It's been the launching area for a campaign, now in its third decade, of kidnappings, suicide bombings, and rocket and mortar assaults on Israel by Gazan militants—much of this sanctioned, if not expressly carried out, by Hamas.

**GAZA HAS BEEN THE LAUNCHING AREA FOR KIDNAPPINGS, SUICIDE BOMBINGS, AND ROCKET AND MORTAR ASSAULTS ON ISRAEL.**

The tunnels supply the government with all the materials used in public works projects, and Hamas taxes everything that comes through them, shutting down operators who don't pay up. Tunnel revenue is estimated to provide Hamas with as much as $750 million a year. Hamas has also smuggled in cash from exiled leaders and patrons in Syria, Iran, and Qatar that helps keep it afloat.

Samir told me that Hamas leaders and local officials are in business with tunnel operators, protecting them from prosecution when workers like his brother die needlessly. He's convinced that corruption and bribery are rampant. His friends agreed. "Damn the municipality!" Suhail blurted out as Samir spoke.

In 2010, after Israeli naval commandos attacked a Turkish flotilla off the Gaza coast, to international outrage, Israel said it had relaxed the blockade. But today there is still only one ill-equipped access point for goods, whereas the West Bank has many more. Israel makes it extremely difficult and expensive for the UN's Relief and Works Agency and other aid agencies—the source of life and livelihood for

**GAZA CITY APARTMENTS** rise beyond the broken gates of a waterfront restaurant. The beach once bustled with fishing boats and cafés, but the Israeli naval blockade, sewage, and lack of resources for rebuilding have taken their toll.

thousands of the 1.6 million Gazans—to import basic materials for rebuilding projects, such as machinery, fuel, cement, and rebar.

According to a Gazan customs official I spoke with, the spring of 2011 saw imports at their lowest level since the blockade began. And what did get through, he said, was often degraded: used clothing and appliances, junk food, cast-off produce. It was impossible "to meet basic needs," the official said, insisting that the *hesar,* or siege, as Gazans call it, was crippling them. Even some of Israel's oldest supporters agreed. British Prime Minister David Cameron lamented that under the blockade, Gaza had come to resemble a "prison camp."

PHOTOGRAPHER PAOLO PELLEGRIN and I made many trips to Rafah's tunnels. The drive from Gaza City, an hour to the north, afforded a dolorous tour. The aftermath of the civil war and of Israel's most recent invasion of the strip—Operation Cast Lead in 2008–09—was evident everywhere. Stepping out of our hotel each morning, often after a night torn open by Israeli air strikes on reported militant hideouts, we took in the absurd sight of a five-story elevator shaft standing alone against the skyline, the hotel that had once surrounded it reduced to rubble. The Palestinian Authority's former security headquarters cowered nearby, a yawning missile hole in its side. Bullet-chewed facades and minarets marked the horizon.

Driving south, we passed Arafat's bombed-out former compound, littered with rusted vehicles, then proceeded along the coastline, once one of the prettiest on the eastern Mediterranean but now home to the skeletons of seaside cafés and to fetid tide pools. Heading inland, we passed abandoned Israeli settlements, their fields sanded over, their greenhouses lying in tatters. South of Rafah the ruins of the Gaza Airport languished as if in a Claude Lorrain landscape—used only by herders grazing their sheep and Bedouin their camels. Our interpreter, Ayman, told us that after the airport was built, he was so proud of it that he took his family there on weekends for picnics. "Look

**AT RAFAH'S HECTIC** Saturday market, vendors sell everything from flavored water and vegetables to cotton candy. Many goods come through the tunnels from Egypt, but the plump strawberries on display in front of a Hamas billboard are homegrown.

RUST

**GAZANS FIX A DONKEY CART** for collecting mountains of rubble left in 2008-09 by Operation Cast Lead, a military campaign in Gaza launched by Israel, officially in response to ongoing rocket fire from the strip. Rubble is recycled into gravel for new construction.

**THE PLACARD NOTES** that Allah will reward those who are patient. The young men are Salafi jihadists with one or more of the radical Islamic splinter groups that call for armed struggle against non-Muslims. They gathered in support of the uprising in Syria.

at the destruction," he said, shaking his head. "Everything. Everything is…destructed." "Destructed" is a favorite malapropism of Ayman's. It's apt. "Destroyed" doesn't quite capture the quality of ruination in Gaza. "Destructed," with its ring of inordinate purpose, does.

As we arrived in Rafah, life teemed again. A byword for conflict, Gaza is also synonymous in Middle Eastern memory with that other staple of human history, commerce. Armies marching into the desert depended on its gushing wells and fortress walls, but to merchants through the millennia, Gaza was a maritime spur of the spice routes and agricultural trade. Travelers sought out its cheap tobacco and brothels, and even today Israeli chefs covet its strawberries and quail. From the 1960s to the late 1980s, Gaza and Israel enjoyed a symbiotic commercial relationship not unlike that of Mexico and the U.S. Gazan craftsmen and laborers crossed the border every morning to work in Tel Aviv and Jerusalem, while Israelis shopped in the tax-free bazaars of Gaza City, Khan Younis, and especially Rafah, which some old Gazans still call Souk al Bahrain: "the market of the two seas." The first intifada, which lasted from 1987 to 1993, put an end to much of that.

Passing a jammed intersection overlooked by a Hamas billboard showing a masked militant wielding a bazooka, we entered the Rafah market. The din and fumes of generators commingled with the shouts of vendors, the braying

of donkeys, and the sweet smoke of *shawarma* spits. Block after block of shops and stands sold consumer items, much of which had come through the tunnels.

It's no secret that Gaza's tunnel operators are brazen, the more so since the Arab Spring began. Just how brazen was not apparent until we emerged from the market, and an expanse of white tarpaulin tent roofs opened up before us. It stretched along the border wall in both directions, tent after tent as far as the eye could see. Beneath each was a tunnel. They were all in the so-called Philadelphi route, the patrol zone created by the Israeli military as part of the 1979 Egypt-Israel Peace Treaty. All were in full view of Egyptian surveillance towers and sniper nests.

Unable to hide my astonishment, I exclaimed to no one in particular, "This must be the biggest smuggling operation on Earth."

Every few hundred yards bored-looking cops barely out of adolescence sat outside tents and shacks, AK-47s on their knees. Hamas forbids journalists here, so we drove to the farthest end of the corridor and parked behind a dirt hill. Furtively, we walked into the first tent we saw. There we met Mahmoud, a man in his 50s who used to work on a farm in Israel. He lost his job when the border was closed during the second intifada, so he and a group of partners pooled their savings. In 2006 they started digging, and a year later they had a tunnel.

After nervous negotiations with Ayman, Mahmoud agreed to show me how it worked. "Come here," he said, leading me to the well shaft. Suspended over it was a crossbar with a pulley, from which hung the harness for lifting and lowering goods and workers. The harness was attached to a spool of metal cable on a winch that could lower a worker the 60 or so feet down the shaft to the tunnel opening. Mahmoud's tunnel was about 400 yards long, but some can extend half a mile. On this day boxes of clothing, mobile phones, sugar, and detergent were coming in; the day before it had been four tons of wheat. Mahmoud earned anywhere from several hundred to a few thousand dollars a shipment, depending on what he brought in. Like many tunnel operators, he made enough to keep his tunnel open and support his family but not much more.

Five to 12 men work in 12-hour shifts, day and night, six days a week, and Mahmoud communicated with them via a two-way radio that had receivers throughout the tunnel. The men earned around $50 a shift but sometimes went weeks or months between payments.

**"DESTROYED" DOESN'T QUITE CAPTURE THE QUALITY OF RUINATION IN GAZA. "DESTRUCTED," WITH ITS RING OF INORDINATE PURPOSE, DOES.**

On the dirt floor beneath the tarpaulin were dusty cushions where they could rest after a shift. There was also a charred black kettle on the remnants of a wood fire, a strand of prayer beads, and stacks of halved plastic jerricans, the ad hoc sleds that are used to move goods along the tunnel floor.

"Would you like to go down?" Mahmoud asked. Before I could say no, I said yes. Moments later his men were enthusiastically strapping me into the harness and lowering me into the cool, dank well. I tried to imagine what it would be like if this were my daily routine, going to work by descending six stories into the earth at the end of a cable. At the bottom it was chaotic: dim lightbulbs flickering, radio traffic blaring, dust-covered workers hauling sacks out of the sleds. The mouth of the tunnel was large enough to accommodate several stooping men, but it soon became so narrow that I had to crouch, my shoulders scraping the walls.

When I got back to the surface, a group of police suddenly appeared. They had seen our car. "You shouldn't be here," their leader said. Ayman apologized, and soon the officer was regaling me with his account of uncovering a load of cocaine and hashish at a tunnel the day before. Smuggling drugs is lucrative but very risky. They arrested the operator, the officer said, and

**SURAQA QUDAIH, 18, WAS KILLED** by a missile from an Israeli drone while returning home with two cousins, one of whom was also killed. He was a member of the armed wing of the Popular Resistance Committees, a militant organization.

**TWELVE-YEAR-OLD KHAMIS ABU ARAB** (at left) was playing outside when he found an undetonated shell. He brought it home, where it exploded in his face. A series of operations in an Israeli hospital removed shrapnel from his eyes but couldn't restore his sight.

**MEMBERS OF THE MILITANT GROUP** Islamic Jihad patrol the border with Israel to prevent incursions by the Israel Defense Forces. The average Gazan family has six people, and with so few jobs to be had, disaffected young men are drawn to extremist groups.

the well was filled in. He then ordered Paolo and me to go, saying we'd have to get permission from the central government in Gaza City if we intended to come back. "Don't go into the tunnels," another cop warned. "You'll die."

In the tunnels death comes from every direction. One operator told of the time he tried to smuggle in a lion for a Gaza zoo. The animal was improperly sedated, awoke in the tunnel mid-trip, and tore one of the workers apart. Another operator showed me a video on his mobile phone of three skinny young men lying dead on gurneys. They were his cousins, he said, and had worked in his tunnel. I asked why they had no contusions or broken limbs. "They were gassed," was the reply. According to some Palestinians, when Egypt has been pressed by Israel to cut down on smuggling, its troops have occasionally poisoned the air in tunnels by pumping in gas. Egypt has denied this.

AFTER DAYS OF WRANGLING with assorted offices, we returned to the tunnel corridor. Word had spread that an American reporter was snooping around, and even with our official escort, many operators shunned us. But some warmed up.

The most welcoming was Abu Jamil, a white-haired grandfather and the unofficial mukhtar of the Philadelphi corridor. Abu Jamil is credited with having opened the first full-time tunnel. It quickly attracted too much business to be serviced by a well, so he dug an enormous trench

for loading and unloading goods. Abu Jamil had opened several more tunnels, and his sons, grandsons, nephews, and cousins worked for him. He claimed to no longer care about the profit. "For me it's a way to challenge our circumstances," he said, as a dump truck backed into the trench to pick up a load of Egyptian sandstone. Asked what else he's brought in over the years, he smiled wearily. "Oh, everything." By which he meant cows, cleaning supplies, soda, medicine, a cobra for the zoo.

At a tunnel nearby we saw a shipment of potato chips arrive; at another, mango juice; at another, coils of rebar; at another, the familiar blue canisters of cooking gas. We reached one tunnel as 300 dripping Styrofoam boxes filled with fish packed in ice were being unloaded. Taxis and cars sent by restaurants and wives had pulled up to take delivery. The partners who ran this tunnel were young, in their 30s. They specialized in lambs and calves, they said, but fish was cheaper, and since Gazan fishermen were kept within a tight nautical limit by the Israeli Navy, seafood was always in demand.

Just then a man entered the tent and whispered to one of the partners. He didn't want sardines—he wanted to be smuggled into Egypt. This is common. Some Gazans go by tunnel to the Egyptian side of Rafah for medical treatment. Some use the tunnels to escape, others to have a good time for a night. I heard that there were even VIP tunnels for wealthy travelers, with air-conditioning and cell phone reception.

As the two men haggled, there was yelling outside the tent. I rushed out to find a tunnel worker about to punch Paolo. The man was screaming that he didn't want his picture taken. Every time a journalist comes here, he shouted, a tunnel is bombed. How, he yelled, could he tell that we weren't spies? I'd noticed that when Ayman tried to persuade tunnel operators to speak with me, the word "Mossad" was often uttered. They presumed that if Paolo and I weren't with the CIA, we must be with the Israeli spy agency. The tunnel worker's paranoia is understandable, given that Israel's surveillance of Gaza is constant, as the ceaseless buzz of drones overhead attested. And in recent memory, Israeli commandos have entered the tunnel zone. A few, as the Israeli press has documented, died in bomb explosions—booby traps set by Palestinians.

**I RUSHED OUT TO FIND A TUNNEL WORKER ABOUT TO PUNCH PAOLO. EVERY TIME A JOURNALIST COMES HERE, THE MAN SHOUTED, A TUNNEL IS BOMBED.**

ALTHOUGH UNEMPLOYMENT is endemic—the rate in Gaza is more than 30 percent—the Gaza Strip is full of would-be entrepreneurs. On the shore north of Gaza City, next to bombed-out cafés, fish farms are being built. On the roofs of buildings pockmarked by machine-gun fire, hydroponic vegetable gardens are being planted, and in Rafah, just west of the tunnels, a sewage-processing plant is now running, its pond lined with concrete pylons taken from the border wall.

Yet for the majority of Gazans, the tunnels remain the lifeline. One day in Rafah I met a man who was digging a well with the help of his two sons, using a horse in place of a winch. I asked if he worried about his sons' safety. He said yes, of course. But he had no other job prospects and couldn't afford to keep his sons in school. Fixing me with a skeptical look that suggested all the distance in the world between us, he said curtly, *"Insa."* One of Arabic's beautifully expressive idioms, the word means essentially, "That's life."

Alongside the tunnel economy is another, born of destruction. The UN estimates that Operation Cast Lead created more than half a million tons of rubble, which has become a currency in its own right. It's everywhere, and the rubble collectors are usually teams of children wielding mallets and hammers, breaking down the stuff, sifting it, loading it onto donkey carts, and bringing it to one of the many

**AT A BEDOUIN WEDDING** in Al Maslakh, a village south of Gaza City, 12-year-old flower girl Hassna Abu Wakid enters the procession to the groom's house. Weddings are still festive public occasions that can last three days.

concrete-block factories that have sprung up. This is how Gazans, unable to legally import construction materials, are rebuilding. A government economist told me that rubble alone accounted for a 6 percent drop in unemployment in 2010.

Gazans are still hopeful that the Arab Spring might bring a change in their circumstances, though so far it has not. There is talk of opening the border with Egypt, but when that might happen, or indeed whether it will at all, is unclear.

The economy of destruction takes on permutations that might have pleased Thutmose III: One night Paolo and I attended a wedding celebration in a bomb crater. It also takes ugly turns: According to an interview in an International Crisis Group report, "a handful of rockets are launched by young militants hired by local merchants whose profits would decline if Israel's closure were further relaxed." This is hideous enough to be believable, but the militants I met were entrepreneurially minded in a more peaceful way. One afternoon I interviewed an Islamic Jihad fighter at a patrol ground near Bayt Hanun. Wearing head-to-toe camouflage and a headband advertising his willingness to die for Allah, an AK-47 in his hands, and a 9-mm pistol strapped to his chest, he admitted that most days he studies business administration at the university. "Jihad is not a job," he said.

Back in Jabalia, I talked with Samir about his future. "There is no chance I can go back to the tunnels," he said. I asked what he'd do instead, and he waved his hand to indicate the room we were sitting in. As it turned out, his brother Yussef had signed a contract to rent this space. When Yussef wasn't working in the tunnels, Samir explained, he was learning to become a beekeeper. He'd planned to open a honey shop here. Samir wanted to take it over in Yussef's stead. And when I last heard from Samir, in September, the shop was up and running. When Yussef died, his wife was three months pregnant with their first child. She miscarried shortly afterward. She is now married to Yussef's youngest brother, Khaled, who manages the honey shop with Samir. They keep a picture of Yussef on the wall. □

**ISRAEL'S NAVAL BLOCKADE** to stop smuggling of arms and other goods into the strip also restricts Gazans to within three nautical miles of shore. But the sea is one place where Gazans have an open horizon.

NINE YEARS AGO, TWO MEN BEGAN

AN EXTRAORDINARY QUEST: TO BE THE FIRST TO FIND

AND DOCUMENT ALL 39 SPECIES OF THE LEGENDARY

BIRDS OF PARADISE.

AFTER 18 EXPEDITIONS AND

OVER 39,000 PHOTOGRAPHS, THEIR VISION IS COMPLETE.

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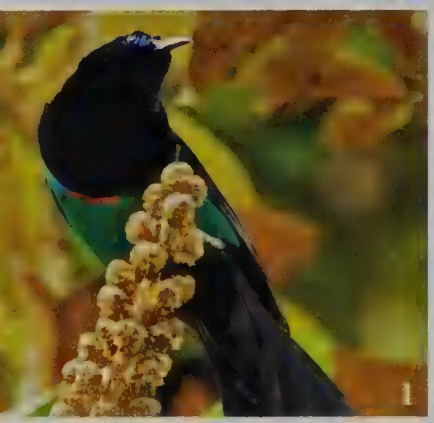
*Paradise found*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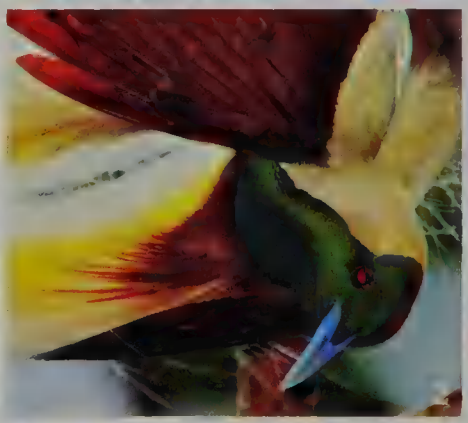

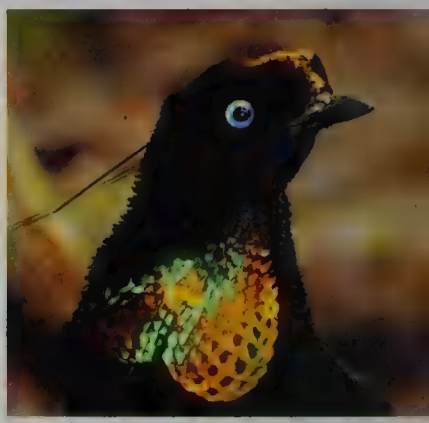

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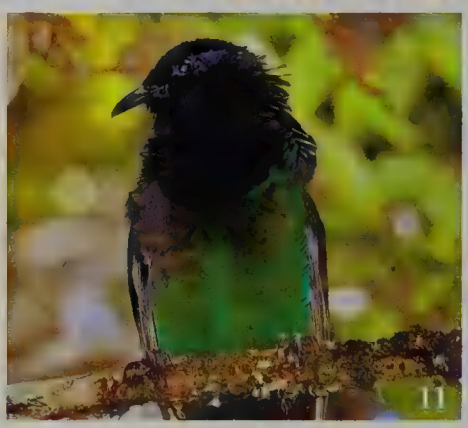
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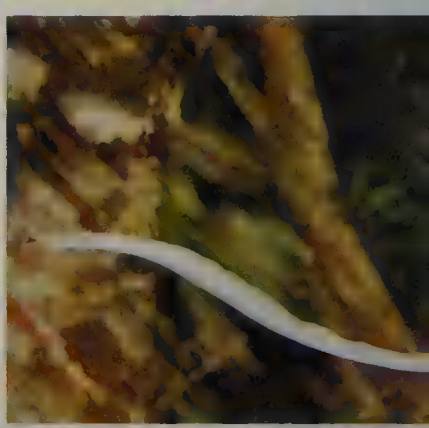

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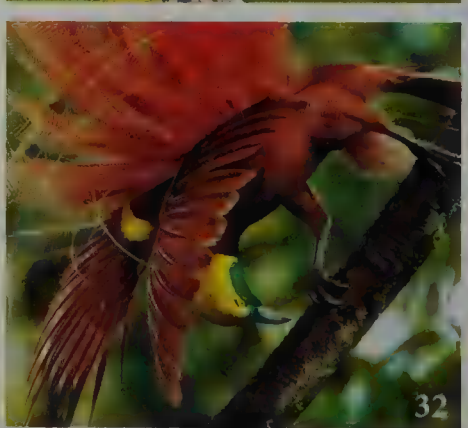
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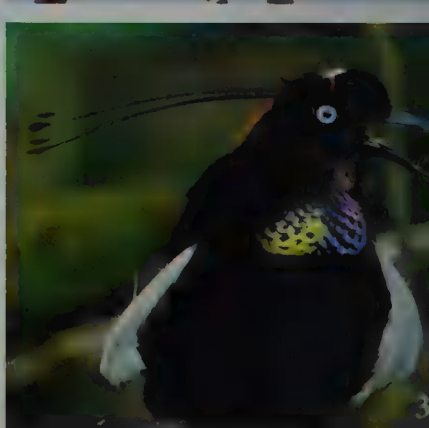
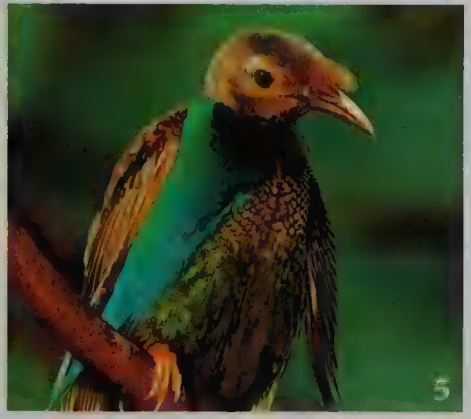
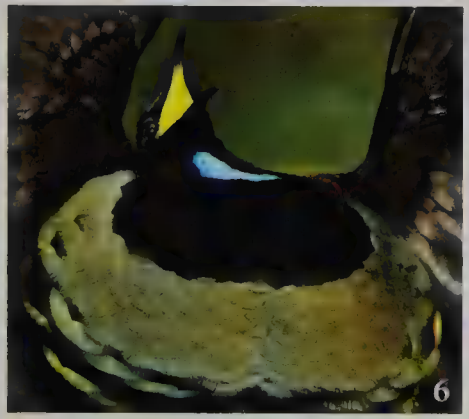
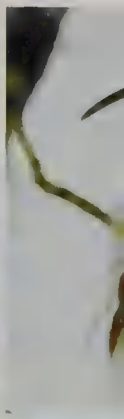
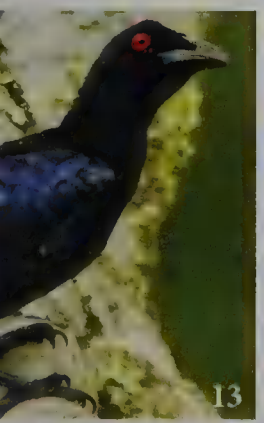




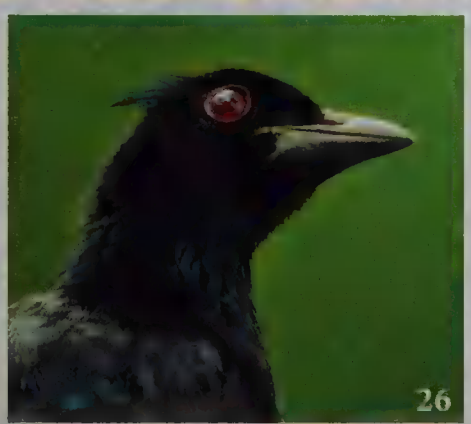



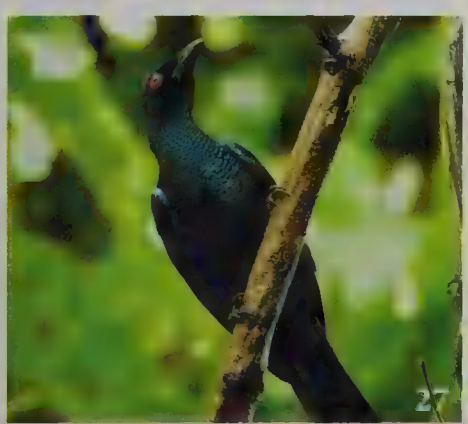



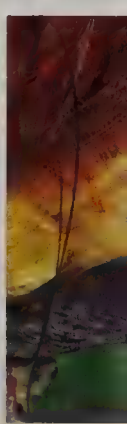


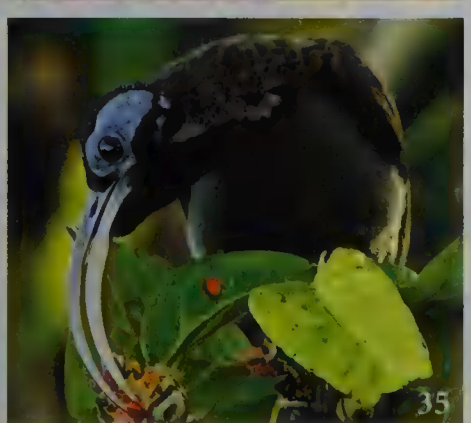
# BIRDS OF PARADISE

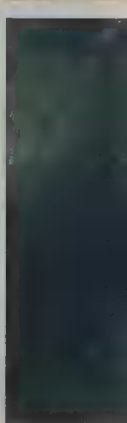
39 SPECIES

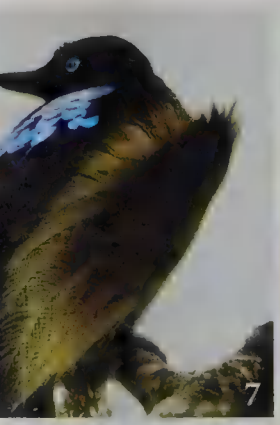


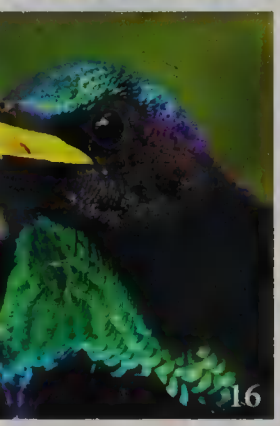



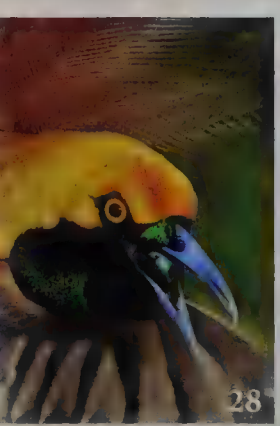


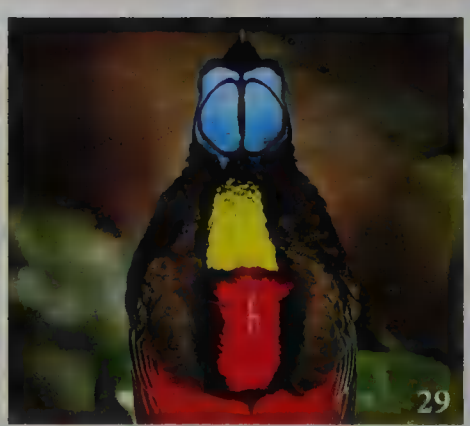


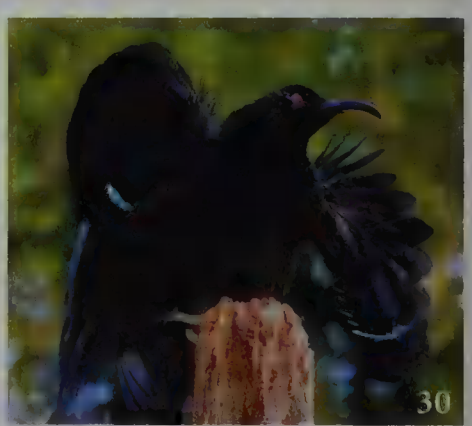


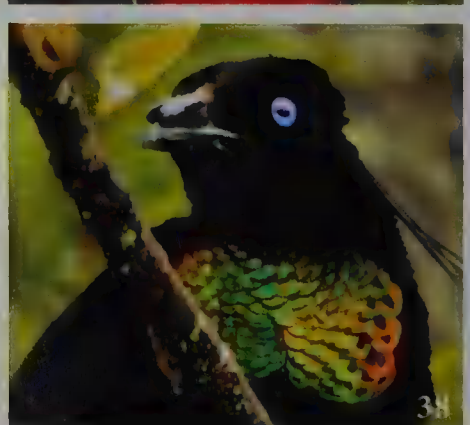


1 Huon astrapia 2 Emperor bird of paradise 3 Wahnes's parotia 4 Black-billed sicklebill 5 Standardwing bird of paradise 6 Victoria's riflebird 7 Brown sicklebill 8 Magnificent bird of paradise 9 Lesser bird of paradise 10 Splendid astrapia 11 Arfak astrapia 12 King bird of paradise 13 Crinkle-collared manucode 14 Long-tailed paradigalla 15 Greater bird of paradise 16 Paradise riflebird 17 Carola's parotia 18 Paradise-crow 19 Short-tailed paradigalla 20 Curl-crested manucode 21 Ribbon-tailed astrapia 22 Stephanie's astrapia 23 Twelve-wired bird of paradise 24 King of Saxony bird of paradise 25 Red bird of paradise 26 Trumpet manucode 27 Jobi manucode 28 Goldie's bird of paradise 29 Wilson's bird of paradise 30 Black sicklebill 31 Western parotia 32 Raggiana bird of paradise 33 Bronze parotia 34 Magnificent riflebird 35 Pale-billed sicklebill 36 Superb bird of paradise 37 Glossy-mantled manucode 38 Lawes's parotia 39 Blue bird of paradise





# BIRDS OF PARADISE

*They are found only from eastern Australia to New Guinea and surrounding islands. They thrive at many elevations, from swampy lowlands to cloud forests more than two miles above sea level. With abundant food, varied habitats, and few predators, the birds have been free to evolve with great diversity. The 39 species can be as small as 8 inches or as large as 49 inches, and plumage ranges from drab to dazzling.*

# THE FAMILY TREE

15 genera, 39 species

**Black sicklebill**
*Epimachus fastosus*

**Magnificent riflebird**
*Ptiloris magnificus*

**Superb bird of paradise**
*Lophorina superba*

**Standardwing bird of paradise**
*Semioptera wallacii*

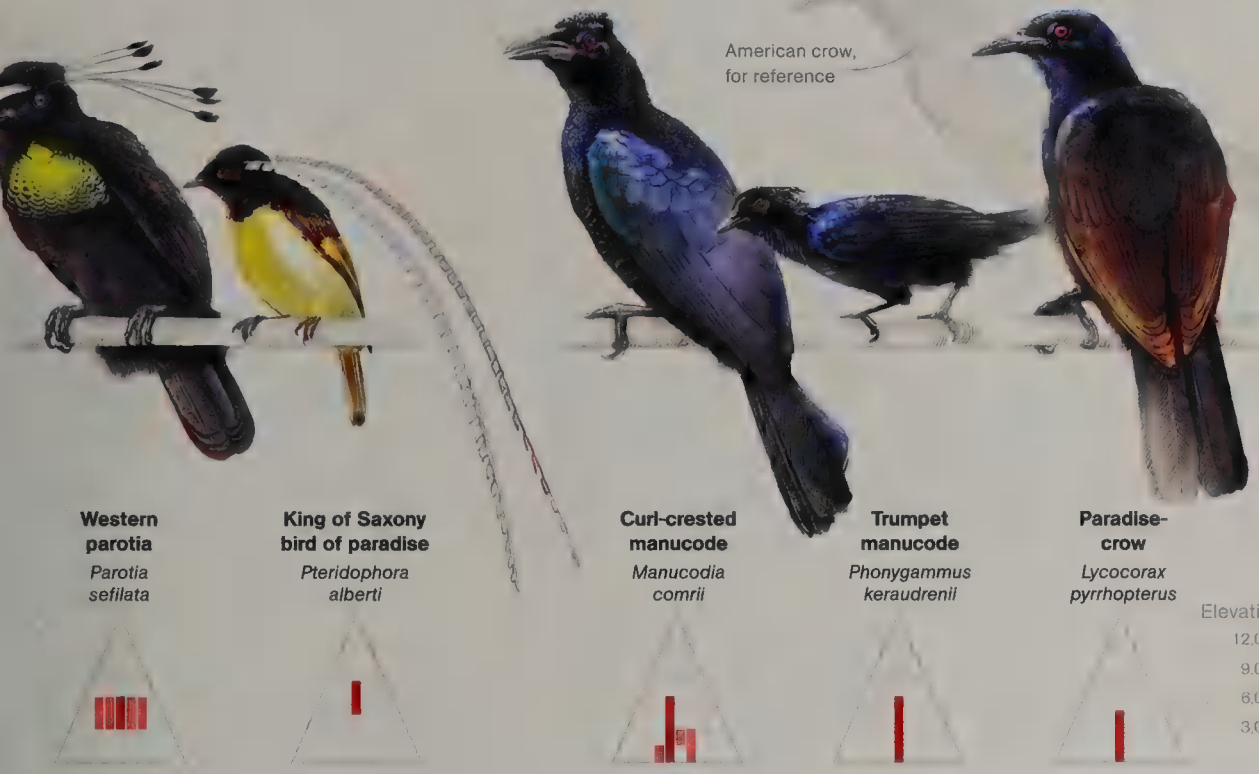
**Black-billed sicklebill**
*Drepanornis albertisi*

**Twelve-wired bird of paradise**
*Seleucidis melanoleucus*

species

5 genera, 8 species

ART: FERNANDO G. BAPTISTA, NGM STAFF; FANNA GEBREYESUS
MAP: MAGGIE SMITH, NGM STAFF; NG MAPS
SOURCES: EDWIN SCHOLES; TIM LAMAN




## ELEGANT EVOLUTION

Genetic analysis has shown that birds of paradise belong to an avian group that includes crows and jays. The family Paradisaeidae's spectacular array of form and color evolved over the past 20 million years.

*The rising sun spotlights the courtship display of a greater bird of paradise on Wokam Island, south of New Guinea. Males strip leaves from treetop branches to clear the stage for mating rituals.*

*Constantly trailed by his own flying saucers, a king bird of paradise clings to a vine in the New Guinea rain forest. His vivid colors and bizarre tail feathers evolved from millennia of competition for female favor.*

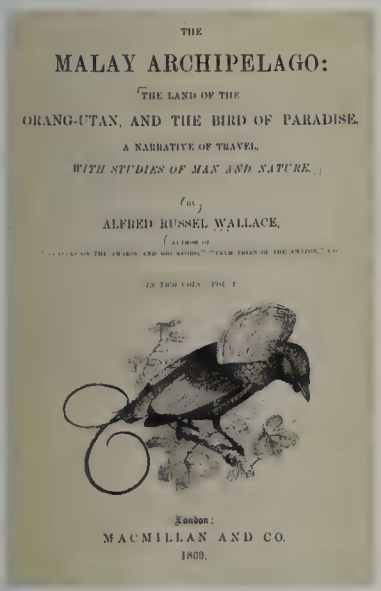
*By Mel White*

In New Guinea kangaroos climb trees, and butterflies the size of Frisbees dart through rain forests where egg-laying mammals scuttle across the muck. Frogs sport noses like Cyrano's, and the rivers are full of rainbow fish.

Yet none of New Guinea's wild wonders have fascinated scientists as deeply as the creatures that 19th-century naturalist Alfred Russel Wallace called "the most extraordinary and the most beautiful of the feathered inhabitants of the earth": the birds of paradise.

The 39 species are found only in New Guinea and a few nearby areas, and despite decades of exploration and research, no one had ever succeeded in seeing them all—until now.

In 2003 Cornell ornithologist Edwin Scholes and Tim Laman, a biologist and photographer, began planning a quest to document every species of the birds of paradise. It took them eight years and 18 expeditions to some of the planet's most exotic landscapes. With still images,


THE

MALAY ARCHIPELAGO:

THE LAND OF THE

ORANG-UTAN, AND THE BIRD OF PARADISE.

A NARRATIVE OF TRAVEL,

*WITH STUDIES OF MAN AND NATURE.*

BY

ALFRED RUSSEL WALLACE,

IN TWO VOLS. VOL. I

London:

MACMILLAN AND CO.

1869.

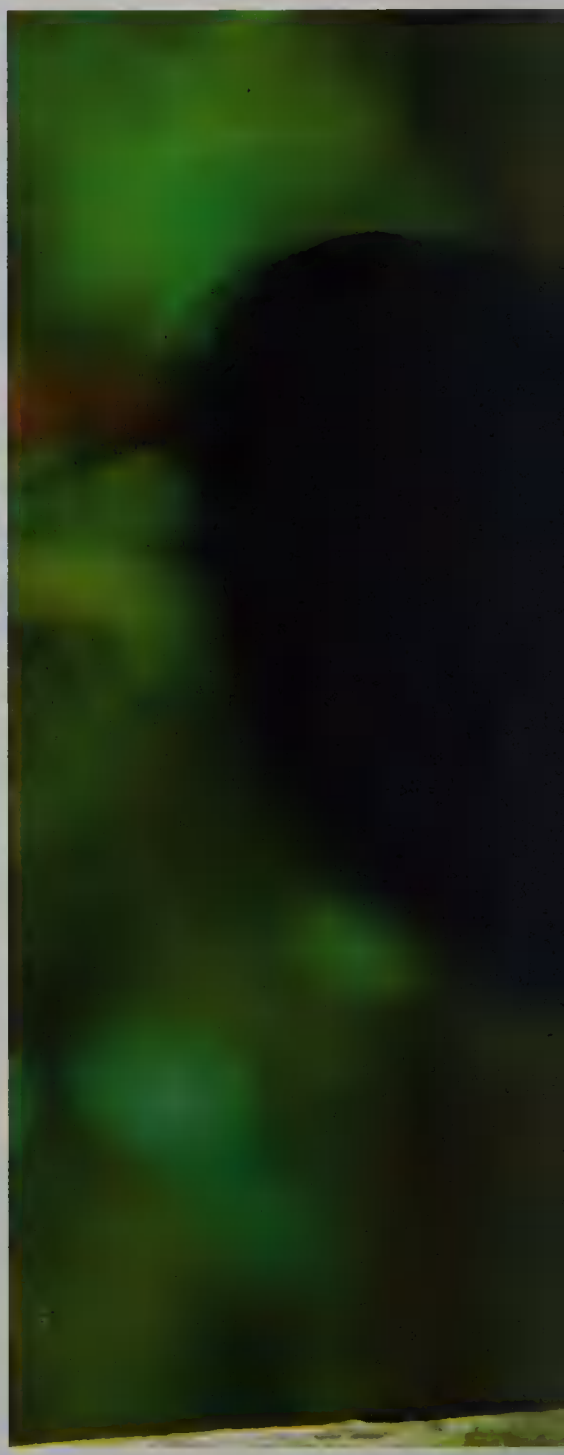
*Nineteenth-century explorer Alfred Russel Wallace was among the first to study birds of paradise in the wild. Following in his footsteps, Tim Laman (top right) and Edwin Scholes visited 51 sites. They found the jewel-like Wilson's bird of paradise (left) on Indonesia's Waigeo Island.*

PHOTOGRAPHS BY TIM LAMAN

videos, and sound recordings—not to mention old-fashioned notebooks and pens—Scholes and Laman captured courtship displays and behavior previously unknown to science.

The natural world offers few spectacles as bizarre as the mating rituals of the males in the family Paradisaeidae. Explosions of golden plumes, comically stylized dancing, tactile wires like robot antennae, iridescent ruffs and puffs, gorgets and fans, and colors that outshine any gem—all this extravagance has but a single purpose. And that, of course, is to attract the attention of as many females as possible.

Birds of paradise represent an extreme example of Charles Darwin's theory of sexual selection: Females choose mates based on certain appealing characteristics, thus increasing the odds that those traits will pass from one generation to the next. In New Guinea an abundance of food and a scarcity of predators have allowed the birds to flourish—and to exaggerate their most attractive traits to a degree that



*A male magnificent riflebird uses what Scholes calls "shape-shifting" to impress a potential mate (above). Rapid head-wagging transforms the bird's iridescent breast shield into a glittering advertisement of sexual fitness.*

**Society Grant** This project was funded in part by your National Geographic Society membership, and through a partnership with the Cornell Lab of Ornithology.

even literal-minded scientists have called absurd.

The brilliant plumes have been prized as decorative objects in Asia for thousands of years. Hunters who traded the first specimens to Europeans in the 16th century often removed the birds' wings and legs to emphasize plumes. This inspired a notion that they were literally the birds of the gods, floating through the heavens without ever alighting, gathering sustenance from the paradisiacal mists.

In the 21st century Laman and Scholes set a goal of documenting the birds in a way that people have never seen them before: from the females' perspective. On Batanta Island, west of New Guinea, Laman climbed 165 feet into the rain forest canopy to photograph the mating ritual of the red bird of paradise. On the Huon Peninsula, 1,200 miles east, he mounted a camera pointing down from a tree branch to get a female's view of the colorful breast feathers and ballerina-like "tutu" of a male Wahnes's parotia.

Though both men had experience in the

Hear the birds' calls and watch them dance on our iPad and Kindle editions.

tropics before they began their endeavor, neither could have anticipated the adventure that awaited. They endured harrowing helicopter rides and long treks along flooded trails, and twice found themselves adrift at sea when boat engines failed. In exchange for moments of thrilling discovery, such as the first view of the Arfak astrapia's upside-down courtship posture, they logged a total of over 2,000 hours simply sitting in blinds, waiting and watching.

The sight of a glossy blue-black Jobi manucode marked the quest's end in June 2011. Scholes and Laman hope their work will encourage conservation in New Guinea, where the birds' habitat has so far been protected by its sheer remoteness. As Wallace wrote: "Nature seems to have taken every precaution that these, her choicest treasures, may not lose value by being too easily obtained." □

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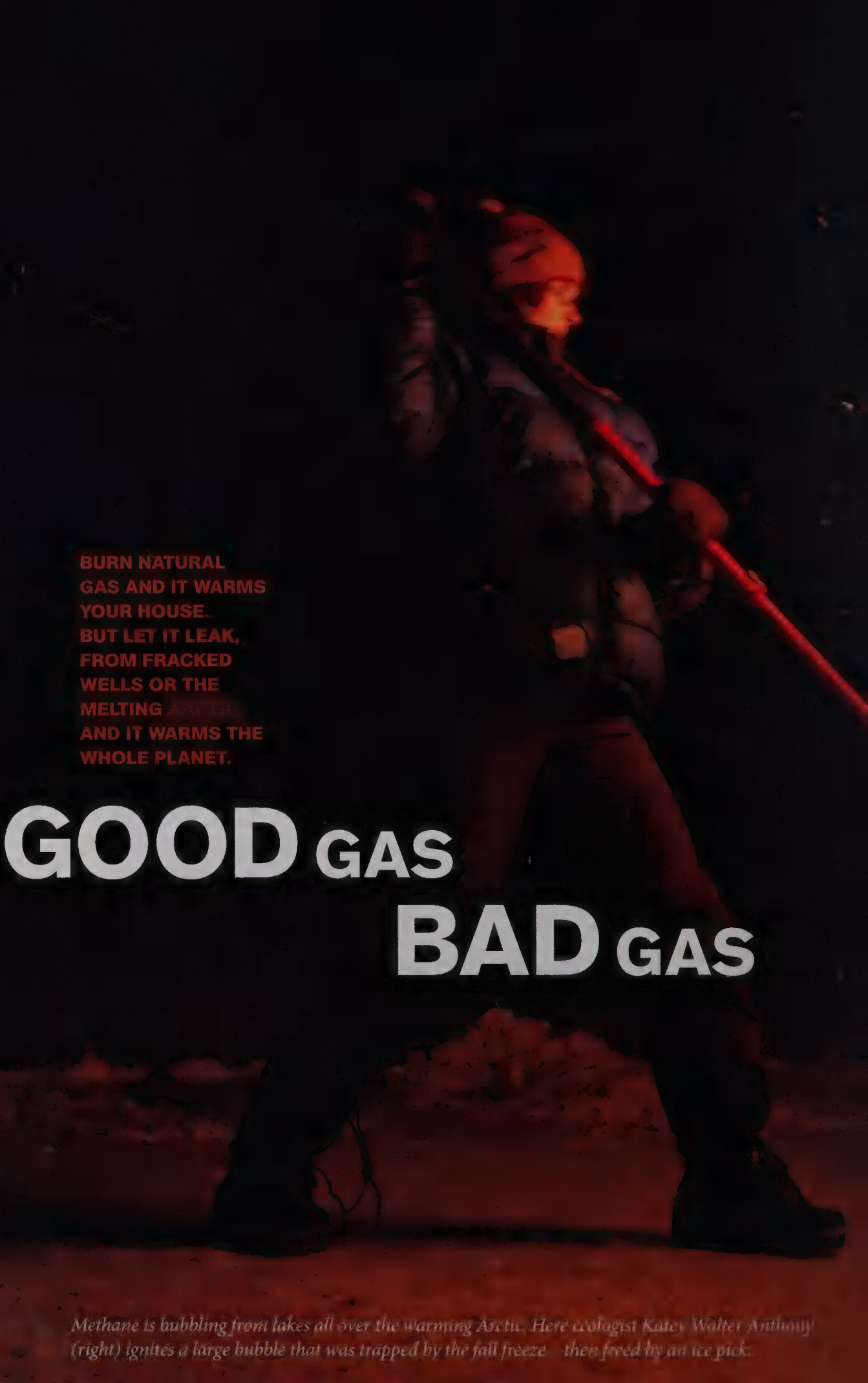
*Mel White writes frequently about natural history. Tim Laman and Edwin Scholes co-authored a new National Geographic book:* Birds of Paradise.

Watch *Winged Seduction: Birds of Paradise* on **National Geographic Channel.** Check local listings.

*Special muscles let the King of Saxony bird of paradise swing each antenna-like head feather through a 180-degree arc during courtship. Rows of miniature pennants decorate plumes that can grow to 20 inches.*

*A twelve-wired bird of paradise calls in a New Guinea swamp. Males brush the dozen stiff feather shafts on their lower torsos against females' faces before mating. Scientists aren't sure why—perhaps it tickles.*



BURN NATURAL GAS AND IT WARMS YOUR HOUSE. BUT LET IT LEAK, FROM FRACKED WELLS OR THE MELTING ARCTIC, AND IT WARMS THE WHOLE PLANET.

# GOOD GAS BAD GAS

*Methane is bubbling from lakes all over the warming Arctic. Here ecologist Katey Walter Anthony (right) ignites a large bubble that was trapped by the fall freeze—then freed by an ice pick.*

*The tree sap that engulfed the termite above and then hardened into amber also preserved the methane bubbling from its hind end. Termites and their wood-digesting gut microbes emit millions of tons of methane each year.*

*Fuel of the future or climate bomb? A clump of icelike methane hydrate melts at room temperature and sea-level pressure, releasing the ignitable gas inside. The stuff is stable only under the seafloor or under Arctic permafrost, where there are vast deposits.*

**THE LAST RAYS OF SUN FILTER THROUGH THE SNOW-COVERED SPRUCES ALONG THE SHORE OF GOLDSTREAM LAKE, JUST OUTSIDE FAIRBANKS, ALASKA.**

Out on the lake Katey Walter Anthony stares at the black ice beneath her feet and at the white bubbles trapped inside it. Large and small, in layer upon layer, they spread out in every direction, like stars in the night sky. Walter Anthony, an ecologist at the University of Alaska Fairbanks, grabs a heavy ice pick and wraps the rope handle around her wrist. A graduate student holds a lighted match above a large bubble; Walter Anthony plunges the pick into it.

Gas rushing from the hole ignites with a *whoomp* that staggers her. "My job's the worst, because usually you catch on fire," she says, smiling. In the gathering twilight she and her team ignite one bubble after another.

The flames confirm that the bubbles are methane, the main component of natural gas. By counting and measuring them, Walter Anthony is trying to gauge how much methane is rising from Goldstream Lake—and from the millions of similar lakes that now occupy nearly a third of the Arctic region. The Arctic has warmed much faster than the rest of the planet in recent decades, and as the permafrost has melted, old lakes have grown and new ones have formed. Methane bubbles from their muddy depths in a way that is hard to quantify—until the first clear ice of fall captures a snapshot of the emissions from an entire lake.

Sometimes as Walter Anthony walks that ice, in Alaska, Greenland, or Siberia, a stamp of her boot is enough to release an audible sigh. Some lakes, she says, have "hot spots" where the methane bubbling is so strong that ice never forms, leaving open holes big enough to spot from an airplane. "It could be 10 or 30 liters of methane per day from one little hole, and it does that all year," she says. "And then you realize there are hundreds of spots like that and millions of lakes."

By venting methane into the atmosphere, the lakes are amplifying the global warming that



SAMPLE PROVIDED BY U.S. GEOLOGICAL SURVEY GAS HYDRATE PROJECT

BY MARIANNE LAVELLE
PHOTOGRAPHS BY MARK THIESSEN

created them: Methane is a potent greenhouse gas. Carbon dioxide is the main one, because the atmosphere holds 200 times as much of it. But a given amount of methane traps at least 25 times as much heat—unless you burn it first. Then it enters the atmosphere as $CO_2$.

That's the other side of this Jekyll-and-Hyde story: A lot of methane is being burned these days. In the past decade the technology called hydraulic fracturing, "fracking" for short, has enabled drillers in the United States to extract natural gas from deeply buried shales they couldn't tap before. Natural gas supplies have surged; prices have plummeted. Fracking is now spreading around the world, and it's controversial. The gas boom has degraded landscapes and polluted water. But it has also had environmental benefits. Natural gas burns much cleaner than coal. In part because American power plants have been switching from coal to cheap gas, U.S. emissions of $CO_2$ from fossil fuels fell last year, even as the world set another record.

The catch is, methane emissions are rising. What's coming out of Arctic lakes is troubling, Walter Anthony says, because some of it seems to be coming not from bottom mud but from deeper geologic reservoirs that had hitherto been securely capped by permafrost—and that contain hundreds of times more methane than is in the atmosphere now. Still, most methane emissions today come from lower latitudes, and most are related more directly to human activities. A growing amount seems to be leaking, for instance, from gas wells and pipelines. Just how warm Earth gets this century will hinge in part on how we balance the good and bad of methane—on how much of it we capture and burn, and how much we inadvertently let loose.

METHANE is the simplest hydrocarbon—a single carbon atom surrounded by four hydrogen atoms. It usually forms when larger organic molecules are broken down, either by microbes or by heat. The microbes produce it when they eat dead plant matter in wet, oxygen-poor environments. They're the source of the methane bubbling up from Goldstream Lake; from swamps and marshes all over; from human-made rice fields, landfills, and manure lagoons; and from the stomachs of cows and other ruminants. Termites emit a lot of methane too.

Most of the natural gas we tap for fuel, however, was formed not by microbes but by heat and pressure deep underground—as oil and coal were, and often in the same places. In coal mines methane is an explosion hazard; in oil fields it was long considered a nuisance to be burned off or, worse, vented directly into the atmosphere. Liquid oil was more valuable as fuel and much easier to transport to markets. Then pipelines built during the post–World War II construction boom made gas more transportable. The energy industry began to exploit massive natural gas reservoirs in places like Russia, Qatar, and Iran.

The United States produces the bulk of its own gas, but U.S. production peaked in 1973. By 2005 the country seemed to be running short, and the industry was building expensive new tanker terminals to import liquefied natural gas. The fracking boom changed that. Since 2005 gas production from deep shales has increased more than tenfold; it now accounts for more than a third of total production, which last year surpassed the 1973 record. Within a decade, according to a Department of Energy (DOE) forecast, the U.S. will become a net exporter of gas.

Estimates of how much gas is locked up in shales and how long the boom can last have varied widely. In 2011 DOE put the amount of "unproved resources" of shale gas at 827 trillion cubic feet; in 2012 it cut that estimate by more than 40 percent. Production from fracked wells has declined faster than DOE analysts had expected. So some critics believe the boom is a bubble that will soon burst. But DOE still projects that U.S. gas production will rise rapidly and that shale gas will make up half the total by 2035.

And deep shales are not the last methane source. DOE and the industry are trying to

---

*Marianne Lavelle is the energy editor at* national geographic.com. *Staff photographer Mark Thiessen has a professional fascination with fire.*

## THE SHALE BOOM

The technology for pulling natural gas from deep shale, refined in the 1990s in Texas, has since spread to other "plays"—parts of a shale basin where large quantities of gas have been found. More than a third of U.S. gas now comes from shale.

**Richest shale deposits**

Recoverable gas, in trillion cubic feet (tcf)
Total for continental U.S. **542***

| | |
|---|---|
| 1. Marcellus | **141** |
| 2. Haynesville | **66** |
| 3. Eagle Ford | **50** |
| 4. Barnett-Woodford | **27** |
| 5. Woodford | **24** |

Shale play (active or expected drilling)

Shale basin (potential gas resource)

ONE TCF CAN HEAT 15 MILLION HOMES FOR A YEAR.
*TOTAL INCLUDES "PROVED RESERVES" AND "UNPROVED RESOURCES."

VIRGINIA W. MASON, NGM STAFF; ALEXANDER STEGMAIER, NG STAFF
SOURCES: U.S. EIA; FRACTRACKER; U.S. CENSUS BUREAU; STATISTICS CANADA

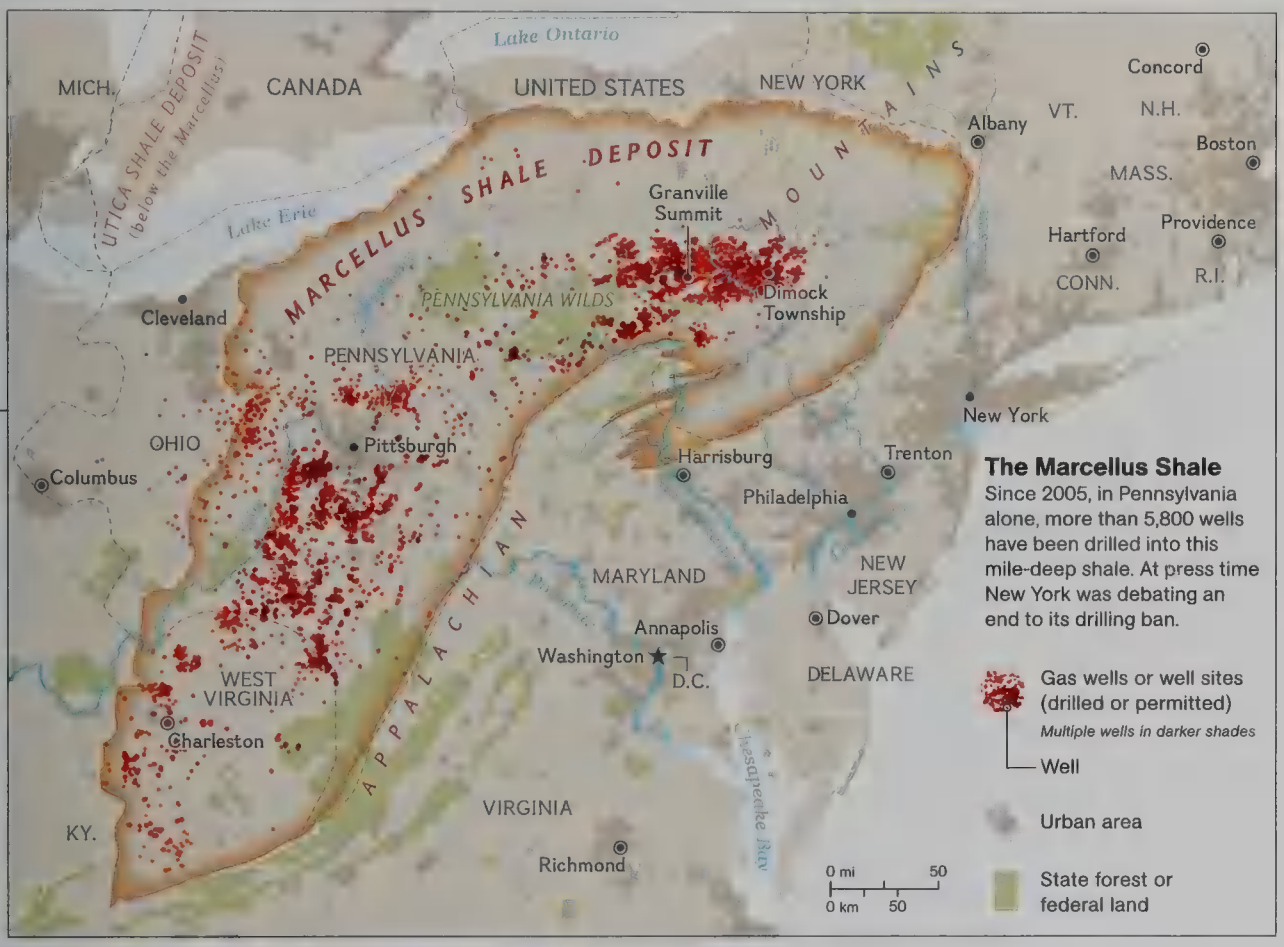
figure out how to tap the largest one of all—the methane hydrates that lie frozen under vast areas of seafloor and Arctic permafrost. Worldwide, hydrates may contain more energy than all other fossil fuels combined. They're usually snow-white and look like ice, but they're strange stuff, and extracting the methane is tricky. Each molecule is trapped in a cage of water molecules that's stable only at high pressure and low temperatures; change either just a bit, and the cage crumbles. The escaping methane balloons in volume by a factor of 164.

Oil companies working on continental margins have to take care that extracting oil through an overlying hydrate layer does not disrupt it and perhaps damage the well. Climate scientists worry that global warming could destabilize hydrate layers, on land or at sea, triggering a massive methane release that would amplify the warming. A few scientists take seriously a catastrophic scenario in which the release happens rapidly, within a human lifetime, and the planet's temperature spikes.

The atmospheric methane concentration has risen nearly 160 percent since preindustrial times, to 1.8 parts per million. For a few years, from 1999 to about 2006, it seemed to level off. Some researchers credit Asian rice farmers, who began draining their paddies during the growing season to conserve water—which reduced methane emissions as well. Another theory credits the oil industry, which started capturing and selling methane it used to simply vent. Since 2006, though, atmospheric methane has been rising again. Many observers believe it's no coincidence that the number of wells punched into deep shales has been soaring too.

THE LARGEST U.S. shale formation, the Marcellus, lies about a mile under the Appalachian Mountains, in an arc that runs from West Virginia to New York through Ohio and Pennsylvania. The Pennsylvania stretch is pretty country: rolling hills and pastures and, in the northwest, the forests of the Pennsylvania Wilds, which boast some 2,000 trout streams and one of the darkest night skies in the East.

These days tank trucks, sand haulers, flatbeds stacked with pipe, and cement mixers rumble continually over the winding two-lane roads.



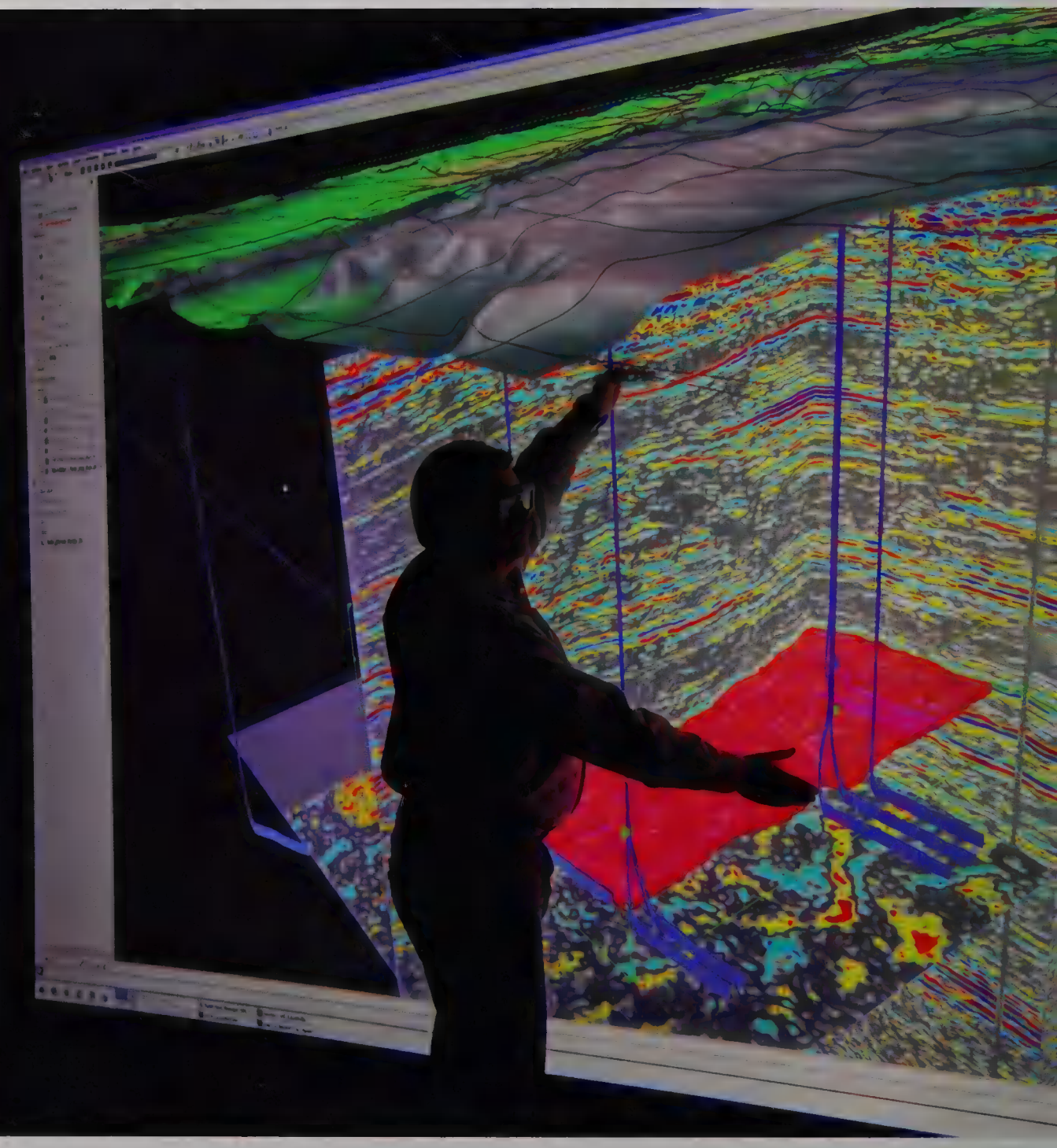

Here and there in patches cut from forest or farm are flattened, four-acre mounds of fresh dirt. For a few weeks at a time tall derricks rise from these drill pads, and the trucks and trailers congregate around them. Contaminated water from the new wells pours into tank trucks or into lagoons lined with dark plastic. The derricks soon disappear, but the wells stay, connected by clusters of green pipes and valves to permanent new pipelines, condensate tanks, and compressor stations. Much of Pennsylvania has been transformed since 2008.

The boom's roots go back to the 1980s and to Texas, where a wildcatter named George Mitchell, facing dwindling reserves, began probing the Barnett Shale near Dallas. Black shales, the compressed mud of ancient seas, were known as petroleum source rocks. But over geologic time much of the oil and gas had migrated out of the shales into porous sandstone traps—and that's where the industry sank its wells. Wells ending in shale never yielded much; the shales were too dense and impermeable to allow gas to flow.

Mitchell Energy's workaround, developed over 20 years with support from DOE, became the recipe for the fracking boom. It has two parts. First, drill down to the shale, then continue drilling horizontally for a mile or so inside it; that puts more gas close to the well. Second, inject millions of gallons of water, chemical lubricants, and sand at high pressure to shatter the shale, allowing methane to rush into the well.

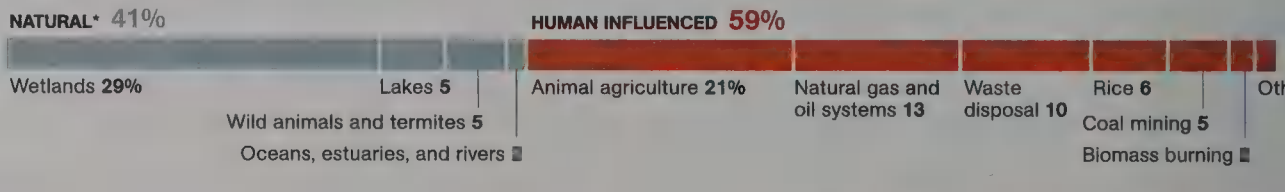
The gas from fracked wells has benefited consumers; 55 percent of the homes in the U.S. have gas heat, and prices last winter reached a ten-year low. In Pennsylvania the boom has revived businesses; created some 18,000 jobs, by the state's reckoning; and paid millions of dollars in lease-signing bonuses and royalties. However, some landowners who leased their land to gas companies have since had second thoughts.

Sherry Vargson is one. In 2008 Chesapeake Energy began drilling on her family's 197-acre dairy farm in Granville Summit, in northeastern Pennsylvania. In June 2010, after a crew had been working on the well, Vargson turned on her kitchen tap to find it backed up with what she thought was air. "It was like drawing a glass of Alka-Seltzer, very sizzly and bubbly," she recalls. Testing showed the water contained more

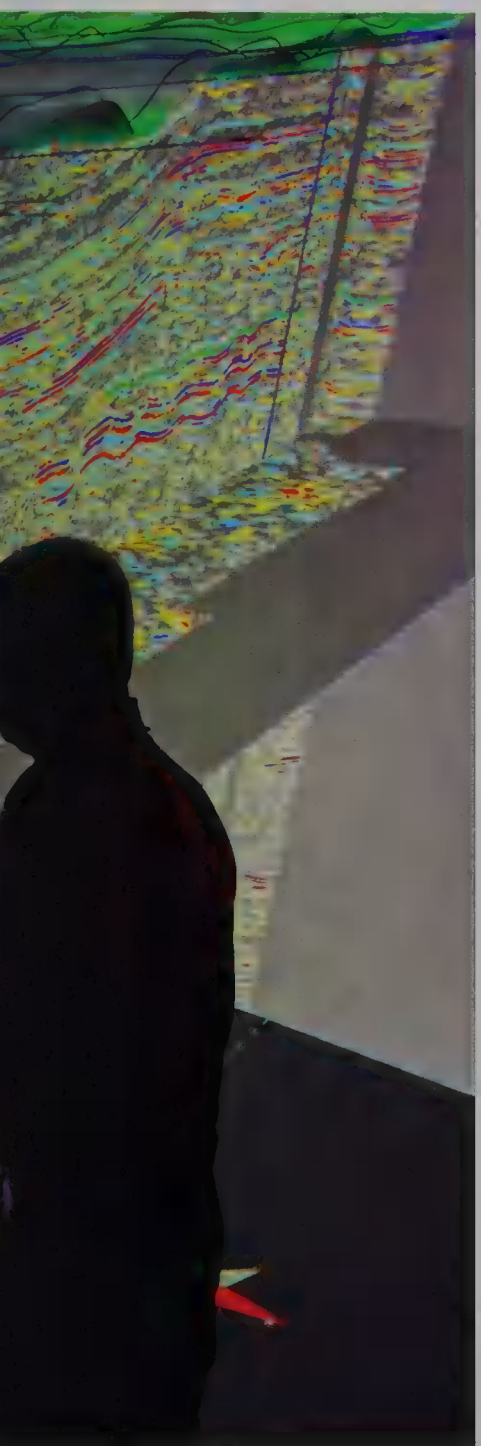


## METHANE EMISSIONS *(global estimates)*

Human activities account for roughly three-fifths of methane emissions globally. In the U.S. the fossil fuel industry is the biggest emitter, surpassing livestock and manure.



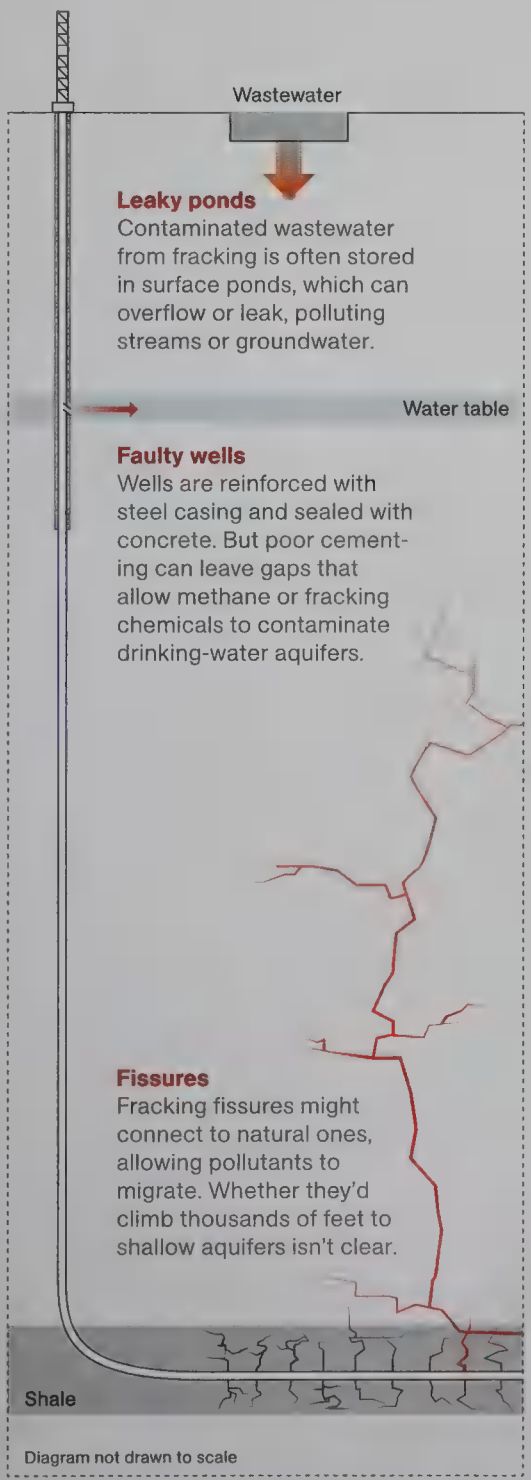

*Other possible sources exist but are omitted due to uncertainty.



*The blue lines on this 3-D map are shale-gas wells. Assembled from seismic data, the map helps scientists at Chesapeake Energy's Oklahoma City headquarters choose the best spots to drill. A typical well plunges a mile and a half, then turns horizontal inside the shale.*

## FEAR OF FRACKING

A key technique in shale drilling is hydraulic fracturing, aka fracking. A fluid mix of water, sand, and chemicals is pumped down the well at high pressure, creating fissures in the shale that let gas flow into the well. But the whole drilling process may also create pathways that allow gas or chemicals to pollute drinking water.


Wastewater
Leaky ponds
Contaminated wastewater from fracking is often stored in surface ponds, which can overflow or leak, polluting streams or groundwater.
Water table
Faulty wells
Wells are reinforced with steel casing and sealed with concrete. But poor cementing can leave gaps that allow methane or fracking chemicals to contaminate drinking-water aquifers.
Fissures
Fracking fissures might connect to natural ones, allowing pollutants to migrate. Whether they'd climb thousands of feet to shallow aquifers isn't clear.
Shale
Diagram not drawn to scale

GRAPHICS: LAWSON PARKER AND MATTHEW TWOMBLY, NGM STAFF
SOURCES: U.S. EPA (EMISSIONS); ANTHONY INGRAFFEA, CORNELL UNIVERSITY (DRILLING)

*So much methane fizzes from Sherry Vargson's tap that she can light it like a stove. The contamination began, she says, after Chesapeake Energy drilled on her Pennsylvania farm. The company denies responsibility. "I keep about three windows open year-round so we don't blow up," Vargson says.*

**SO FAR, THE IMPACT OF SHALE-GAS DRILLING SEEMS MUCH SMALLER THAN THAT OF COAL MINING.**

than twice the methane that's considered an explosion threat. Chesapeake has been supplying her with bottled water ever since, while arguing that the contamination is natural. Meanwhile Vargson's monthly royalty checks have shrunk from more than $1,000 to less than $100, as production from the gas well has plummeted.

The industry's main argument in attempting to reassure a worried public in Pennsylvania and elsewhere has been that shales typically lie thousands of feet below drinking-water aquifers. So contamination, whether by shale gas or fracking wastewater—which contains fracking chemicals, salt, heavy metals, and radioactive elements leached from the rock—should be physically impossible. The argument makes intuitive sense, but the jury is still out. Duke University scientists have recently reported evidence that fluids—albeit not fracking fluids—have migrated upward from the Marcellus Shale through natural fissures.

In an earlier study the Duke researchers sampled 60 private water wells in northeastern Pennsylvania and found no sign of fracking fluids. But they did find that methane levels were on average 17 times higher in wells near drilling sites and that some of the methane had the chemical signature of shale gas. It may have leaked into the shallow aquifers, they said, through faulty casings around the gas wells. The Pennsylvania Department of Environmental Protection (DEP) also blamed faulty casings in 2009 when it fined Cabot Oil & Gas for contaminating the drinking supplies of 19 homes in Dimock Township, 60 miles east of the Vargson farm. In that case the methane came not from the shale but from shallow deposits traversed by the gas wells. DEP has also fined gas companies for mishandling fracking wastewater and allowing spills that polluted creeks and rivers.

In Pennsylvania and elsewhere, shale-gas drilling has raced far ahead of efforts to understand and limit its impact. So far, however, its impact seems much smaller than that of coal mining—which in Pennsylvania has caused far worse river pollution, in West Virginia has lopped the tops off numerous mountains, and in the U.S. still kills hundreds of miners a year, mostly through black lung disease. The comparison is relevant because cheap natural gas is reducing coal burning. As recently as 2007, coal generated nearly half of U.S. electricity. Last March its share fell to 34 percent.

John Hanger, a Pennsylvania lawyer who helped author the state's renewable-energy standards, ran the DEP from 2008 to early 2011. Though he tightened regulations on the gas industry and handed out substantial fines, he was attacked by opponents who wanted a complete halt to fracking. Hanger believes such critics are missing the big picture. "The massive switching from coal to gas has done more to clean Pennsylvania's air, and America's air, than probably any other single thing we've ever done," he says.

Unlike coal, natural gas burns without spewing sulfur dioxide, mercury, or particulates into the air or leaving ash behind. And it emits only half as much carbon dioxide. The greenhouse gas inventory compiled by the U.S. Environmental Protection Agency (EPA) shows that the nation's $CO_2$ emissions in 2010 were lower than in 2005 by just over 400 million metric tons, or 7 percent. (Preliminary data for 2011 indicate a further decrease.) Reduced emissions from power plants, mostly because many have switched from coal to gas, accounted for a bit over a third of that.

Some environmentalists who once welcomed shale gas with precisely that expectation changed their minds after watching the boom in Pennsylvania. But Hanger hopes it spreads around the world, as it seems likely to. "In China they're sitting on potentially huge supplies of shale gas," he says. "It would be an enormous climate benefit if China were to substitute gas for some of its coal burning. And it's an immediate benefit—you don't have to wait until 2040 or 2050."

UNLESS TOO MUCH METHANE LEAKS into the atmosphere. As U.S. $CO_2$ emissions fell between 2005 and 2010, methane emissions rose. By 2010, EPA says, the rise was equivalent in global warming potential to around 40 million metric tons of $CO_2$ annually, which means it offset 10 percent of the $CO_2$ decline. More than half of that

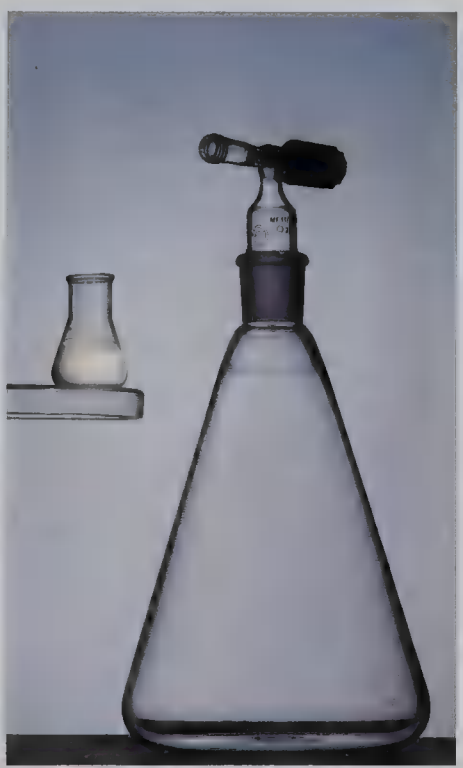
methane increase, says EPA, came from the natural gas industry—the country's biggest emitter.

Judging by EPA's numbers, fracking still seems like a clear win for the climate. But some scientists, notably Robert Howarth and his coworkers at Cornell University, believe EPA has underestimated methane emissions and, more important, the global warming potential of each methane molecule. They argue that methane leaking from wells, pipes, compressors, and storage tanks actually makes shale gas worse for the climate than coal. Other researchers question Howarth's approach. The debate persists in part because methane numbers are so uncertain.

New rules issued by EPA this year will require the gas industry to measure its emissions and also to reduce them. One of the biggest leaks occurs when a fracked well is completed and high-pressure fracking fluids surge back up the well, bringing methane with them. The new rules will require gas companies to start capturing that methane by 2015, using technology that's already required in Wyoming, Colorado, and parts of Texas.

Some experts consider methane capture a great opportunity: an easier way than controlling $CO_2$ to slow global warming, at least in the short term, because small amounts of methane make a big difference and because it's a valuable fuel. China, for instance, the world's largest coal producer, vents huge amounts of methane from its mines to prevent explosions. In the 1990s, when Egyptian geologist Mohamed El-Ashry headed the Global Environment Facility, an agency created by the United Nations and the World Bank, it devoted ten million dollars to projects that siphoned methane from several Chinese mines and delivered it as fuel to thousands of nearby households. Hundreds of such projects await funding worldwide, El-Ashry says.

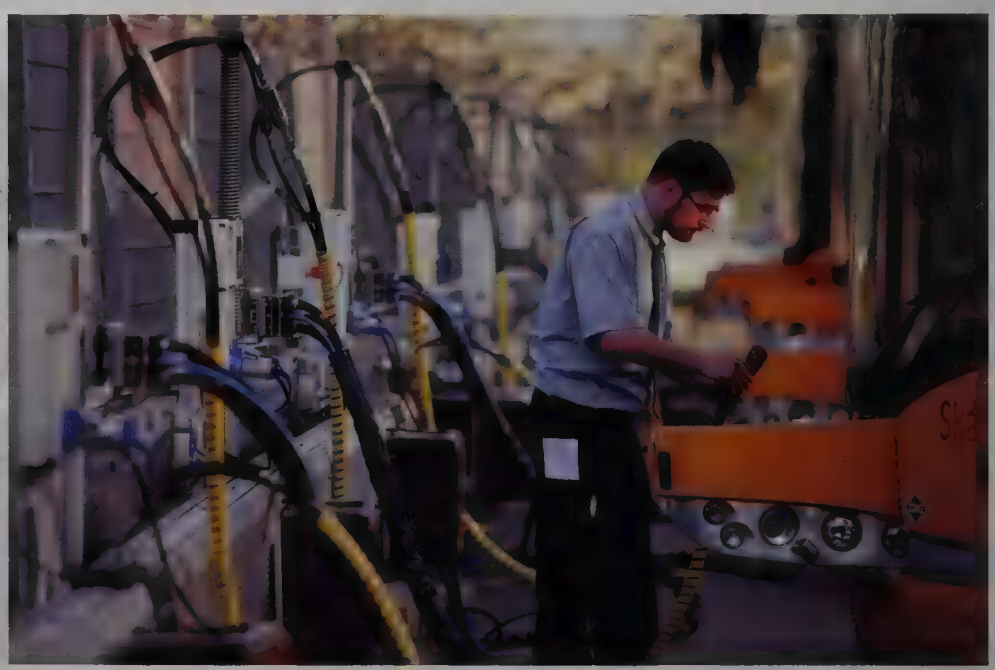
Drew Shindell, a climate scientist at NASA's Goddard Institute for Space Studies, recently led a global team of scientists in analyzing seven methane-reduction strategies, from draining rice fields to capturing the gas that escapes from landfills and gas wells. Unlike $CO_2$, methane affects human health, because it's a



*The little flask holds as much methane as the big one—as a powder rather than a gas. The University of Liverpool researchers who made the powder, a form of methane hydrate, think it could become a convenient way to store and transport natural gas.*

## IN KRISTIANSTAD, OFFAL ISN'T AWFUL—IT'S FUEL

Without fossil fuel reserves of its own, Sweden leads the European Union in the share of energy it gets from renewable sources—48 percent—and has one of the EU's lowest rates of carbon emissions. Hydropower is the biggest renewable source, followed by biofuels. Kristianstad, an agricultural center close to the Baltic Sea, aims to free itself entirely from fossil energy, largely by extracting methane-rich biogas from pork offal, household food scraps, and other waste.



NGM MAPS

*When Kristianstad's cavernous new biogas reactor (right) is full, it contains 1.6 million gallons of sludge, much of it pig intestines from the region's slaughterhouses (left). The propeller-like agitators stir the organic waste, making it easier for microbes to digest—and in the process produce methane. Kristianstad uses this biogas to generate electricity and heat and to fuel cars and municipal garbage trucks and buses (below). Its two refineries produce enough biofuel to replace 1.1 million gallons of gasoline each year.*

*No gassy belch goes unrecorded at the Teagasc Food Research Centre in Ireland. "Cows are walking fermentation chambers," says researcher Matthew Deighton. But adding fat to their diet might reduce their copious methane emissions.*

121
121
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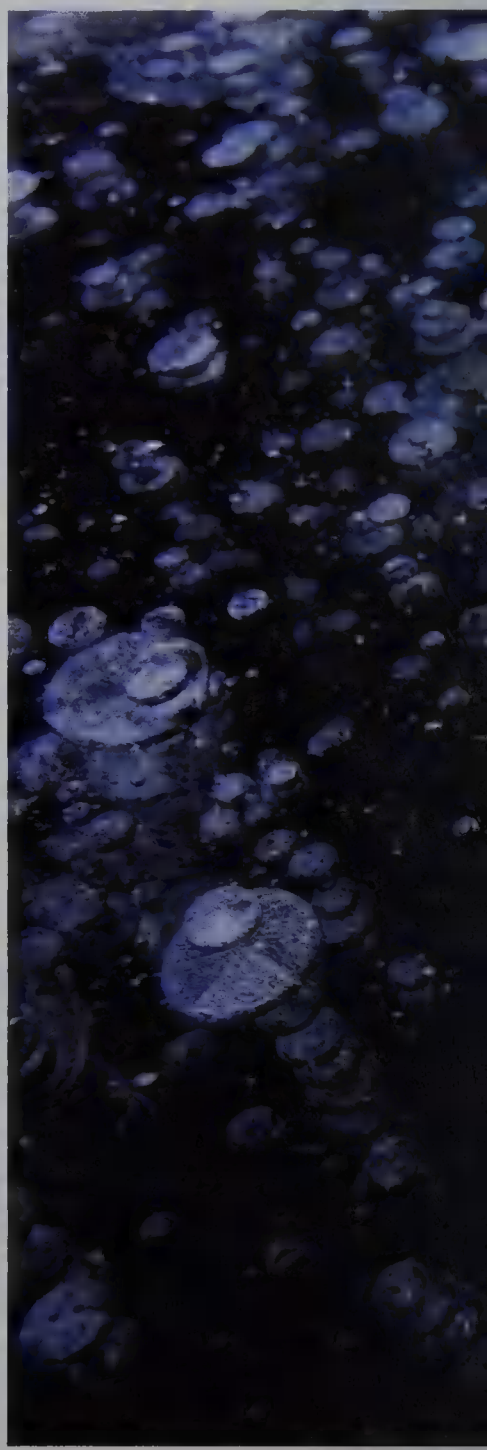
precursor of smog. When health impacts are included, Shindell's group found, the benefits of methane controls outweigh the costs by at least 3 to 1, and in some cases by as much as 20 to 1.

"There are some sources that are difficult, if not impossible, to control," says Shindell. "The Arctic emissions—I'd probably vote those as being near impossible. But then you have long-distance gas pipelines, and we know exactly how to control leaks from those: put in and maintain high-quality seals. And there are other places, especially in oil, gas, and coal production. It's really straightforward to get a substantial fraction of methane emissions under control."



LAST SPRING, as the annual thaw began in Alaska, Katey Walter Anthony heard from her friend Bill Wetzen, who owns Goldstream Lake and sometimes brings her coffee out on the ice. When Wetzen bought the property 20 years ago, he built his bungalow about 20 yards from the lake; by last year it was nearly at the water's edge. Now, Wetzen said, with the permafrost thawing beneath it, the walls and floors were tearing apart. He was going to have to move.

Also last spring, DOE-funded researchers on Alaska's North Slope successfully tested a method of extracting methane from buried hydrates. Though the process "may take years" to become economically viable, said the DOE press release, "the same could be said of the early shale gas research…that the Department backed in the 1970s and 1980s." If even a small fraction of methane hydrates becomes recoverable, DOE estimates, that could double U.S. gas resources.

Some of the methane bubbling from Arctic lakes, Walter Anthony says, might come from hydrates. Around 56 million years ago, in the Paleocene, a long planetary warming culminated in a sudden temperature spike of 9°F; many scientists suspect a massive destabilization of methane hydrates. Most, including Walter Anthony, do not think such a catastrophe is likely now. But Arctic methane could add a lot to global warming over the next few centuries.

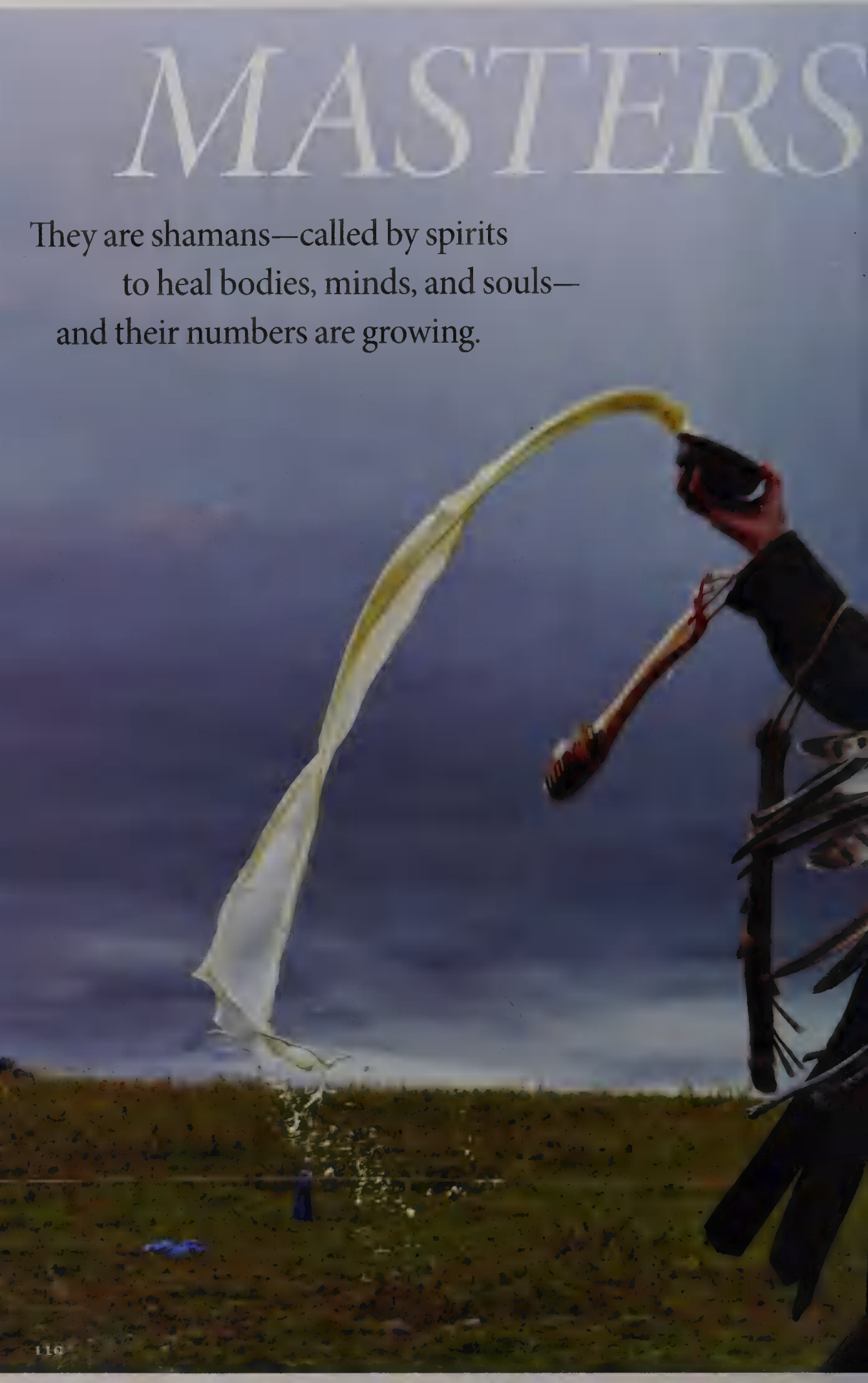
"If we could only capture it, it would make a great energy source," Walter Anthony says. □

**ARCTIC METHANE COULD ACCELERATE GLOBAL WARMING OVER THE NEXT FEW CENTURIES.**

*The first clear ice of fall on an Alaskan lake captures methane that all summer long has bubbled from the bottom mud. In spring it will be released into the air. As permafrost melts, new lakes are forming all around the Arctic.*

# MASTERS

They are shamans—called by spirits
to heal bodies, minds, and souls—
and their numbers are growing.



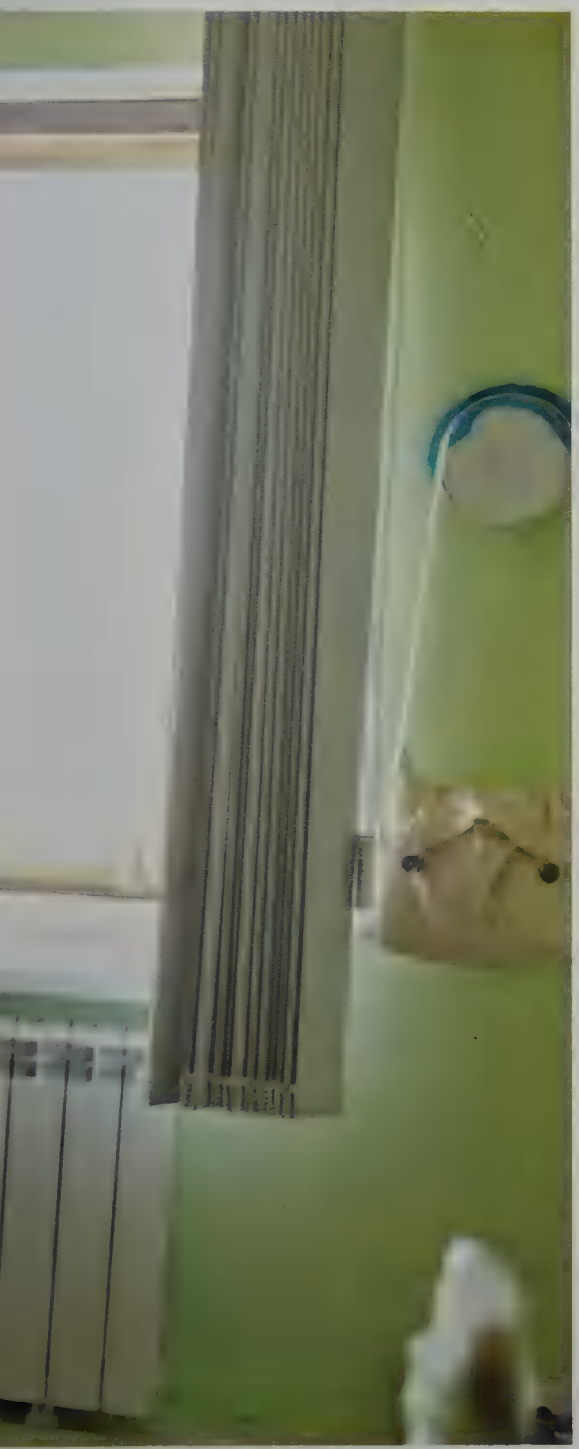
# OF ECSTASY

By David Stern
Photographs by Carolyn Drake

*A novice shaman makes an offering of milk to the spirits at her initiation outside the Mongolian capital of Ulaanbaatar.*

*Symbol of eternity, this "mother tree," a pine in northern Mongolia, draws pilgrims from all over. It gave out under the weight of cloth offerings, the blue ones representing everlasting heaven and peace.*

*Driving out evil spirits with a mini-drum, Lyubov Lavrentiyeva wards off spells and ministers to the sick in her office in Irkutsk, Russia. In the postcommunist era shamanism is undergoing a revival. Lavrentiyeva advertises in the local paper and calls herself "a seamstress of souls."*



Nergui stood in the center of the room, swaying from side to side, chanting, "Great sky, please come here." His eyes were closed, and he gripped a cluster of multicolored cloth strips. His voice was rough and the melody repetitive, like an ancient ballad: "Oh, great blue sky, which is my blanket, come to me."

Nergui is a *boo,* as Mongolians call male shamans. He believes himself to be an intermediary between the visible world and the hidden world of spirits and gods. Mystical figures like him are reviving old traditions throughout Mongolia, Central Asia, and Siberia and finding a receptive audience for their charismatic rituals.

After meditation and chants Nergui moved into a trance, the moment when the spirit from the invisible realm would be free to enter his body. "Oh, my spirit, I would ride ten Mongolian cows to see you. Please let the golden cuckoo guide me to the spirit."

Eight of us had gathered around, sitting on stools and metal-framed beds pushed up against the walls of Nergui's one-room wooden cabin. Outside, the temperature on this mid-November day was 10°F. It was just after midday, the "horse hour," according to the Chinese zodiac clock. For Nergui the noon hour is the perfect time to go on an otherworldly ride.

"Sky of the wolf, please help me. A man in need, with a heart of peace, has come. Great sky, please come here."

Nergui is a slight, unassuming man with a hangdog look that reminded me of the actor Walter Matthau. He was unshaven and dressed in a dull brown *del*—a traditional Mongolian robe—with a yellow belt and a blue silk sash

*Shamans are found around the globe, but the word "shaman"—meaning "one who knows"—comes from the Evenki, an indigenous reindeer-herding people in northern Siberia.*

around his neck. A pair of faded blue corduroys peeked out from under his robe. On his feet were specially made reindeer-skin shaman boots.

He's a Darhad, one of the ethnic groups indigenous to northern Mongolia, next to the Russian border. Numbering some 20,000, the Darhad have largely preserved their traditional nomadic lifestyle: Nergui's day job, so to speak, is taking care of his cows, goats, sheep, and horses. The Darhad also practice shamanism in one of its purest forms, as an integral part of their lives. The region's remoteness helps explain why little has changed. Getting here involved a jolty plane ride from the Mongolian capital, Ulaanbaatar, followed by a bone-shaking 13-hour trip in a rickety Soviet-era minibus over frozen rivers, icy mountain passes, and snow-packed tundra.

Nergui's chanting picked up speed as his swaying became more like a dance. He made *giddyap* sounds and whipping motions with his strips of cloth, as if spurring on a horse.

Juniper twigs burning in a cast-iron stove gave off a fragrant scent; the smoke is believed to attract spirits. Blankets draped on the walls to keep in the heat made the room seem even smaller, and in the corner opposite the door was a collection of amulets, figurines, colored scarves, bits of cloth, and other talismans—a shrine to Nergui's guardian spirits.

Suddenly he collapsed. Two helpers caught him, and he gave a wolflike howl. Then he cackled like the villain in a horror movie. "The spirit has entered him," Zaya Oldov, my guide and translator, whispered.

They brought him to the back of the room, and he sat down, cross-legged, eyes still shut. One by one the members of our group approached him. The shaman—or the spirit speaking through him—described each person's past and doled out advice.

Then it was my turn; I kneeled next to him. "You were a very quiet person when you were young." Nergui's voice was deeper now, more

assured. "You love animals. Wherever you have gone, you have given things to people, and this put a smile on their face." All this was true, but so general it could apply to almost anyone.

He continued, "You have a unique mark on your right side, under your armpit." (Not true—my skin there is blemish free.) Other specific, cryptic comments followed. "A man with the sign of the dog and the sheep will soon help you." Nergui then concluded: "By my power I will look after your family and your loved ones. Take these juniper twigs and burn them in your home." After I took them, he reached for something and held out his hand. "Here is the anklebone of a wolf. Carry it in your right pocket—it will protect you from harm."

He began to exit his trance, gyrating and flailing his arms. His eyes were full of fear (or was it pain?), and he was hyperventilating. His wife, Chimgee—a wiry woman in a gray-blue del and green kerchief—approached him and put a lit cigarette in his mouth. Still shaking, he chewed it, burning end and all, and swallowed.

Eventually Nergui calmed down. A second cigarette was offered, which he smoked this time. Chimgee smiled at her husband. "Did you have a good journey, dear?" she asked.

THE WORD "SHAMAN" comes from the Evenki, a Siberian people, but shamans can be found in practically every corner of the planet—including in shamanic centers now in London, Boston, and many other Western cities. Shamans believe that unseen spirits permeate the world around us, act upon us, and govern our fates. By turns doctors, priests, mystics, psychologists, village elders, oracles, and poets, they are the designated negotiators with this hidden reality, and they occupy an exalted position within their societies.

There is no precise definition of shamanism. "It would be better to speak of 'shamanisms,' in the plural," says Marjorie Mandelstam Balzer, an anthropologist at Georgetown University in Washington, D.C. Beliefs, practices, and rituals vary from person to person, she told me, because the path to becoming a shaman is above all a highly individual one. Similarities do exist, though: The ecstatic trance, or soul journey, as it's sometimes called, is a signature phenomenon. But how shamans employ their instruments and spiritual insights varies greatly, as can the ritual's ultimate purpose. Many shamans work alone, while others join large urban organizations that act as trade unions; the Golomt Center for Shamanic Studies in Ulaanbaatar claims around 10,000 members.

Most shamans in Central Asian countries, such as Kyrgyzstan and Kazakhstan, where Islam predominates, regard themselves as devout Muslims, and their rites are infused with the mystic traditions of Sufism. Swathed in virginal white smocks, they conduct their rituals at Muslim holy sites, and every ceremony includes extensive prayers from the Koran. In Siberia and Mongolia, shamanism has merged with local Buddhist traditions—so much so that it's often impossible to tell where one ends and the other begins.

In Ulaanbaatar I met a shaman, Zorigtbaatar Banzar—an outsize, Falstaffian man with a penetrating stare—who has created his own religious institution: the Center for Shamanism and Eternal Heavenly Sophistication, which unites shamanism with world faiths. "Jesus used shamanic methods, but people didn't realize it," he told me. "Buddha and Muhammad too." On Thursdays in his *ger* (a traditional Mongolian tent) on a street choked with exhaust fumes near the city center, Zorigtbaatar holds ceremonies that resemble a church service, with dozens of worshippers listening attentively to his meandering sermons.

AFTER NERGUI HAD RECOVERED from his trance, he opened the bottle of vodka I'd brought as a gift and poured us each a shot into a shallow teacup. I accepted the cup with my right hand—to receive anything with your left can be a grievous insult—and before drinking, I made an offering to the spirits in three directions. I lightly dipped my fingers in the liquid, flicked a few drops into

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*Based in Kiev, Ukraine, journalist David Stern concentrates on Central Asia. Photographer Carolyn Drake, a frequent contributor, works out of Istanbul.*

*By day Sain Tsetseg (Good Flower), of the Tsaatan ethnic group, tends her reindeer in northern Mongolia (above). At night in her tepee-like* ortz, *she beats a drum to enter a trance while an assistant burns juniper twigs, whose fragrant smoke draws in the spirits.*

the air and then toward the ground, and finally dabbed my forehead.

Shamanism is something you're born with, Nergui said, slugging down a large shot of vodka. You can't just decide to become a shaman—you must be chosen by the spirits. The shamanic calling is usually passed down from one generation to the next. "My father is a shaman," Nergui said, adding that he was 25 when he became aware that he too had an aptitude for communicating with the spirit world. "I've been doing this 25 years, and I have 23 spirits I can call on."

But, he added, a shamanic gift is just the beginning. All shamans must undergo an intense apprenticeship, learning the timeworn practices

Shamans invest their own ritualistic equipment with a holy spirit; it becomes "alive."

of their vocation. These rituals facilitate the shaman's interaction with the spirit world—like the trance I had just witnessed—as well as dictate the methods used in paying respect to the spirits. Shamans invest their own special ritualistic equipment with a holy spirit; it becomes "alive." Nergui's includes a reindeer-hide drum, a mouth harp, the colored strips of cloth, and his costume.

During the Soviet era, all religion, including the shamanic tradition, was suppressed. Many shamans died in labor camps. "A shaman I knew named Gombo got caught during a ritual and was sent to jail for a year and a half," Nergui said. By the time Nergui started practicing, the worst of the purge was over, but shamanism was still forbidden, and shamans had to perform in secret. "We hid our religion so that it wouldn't fade away," he said. "There were two places where we would do the ritual. The first one was at home, and we would have somebody sit by the door to see if anyone was coming. The second place was hidden in the mountains. Then around 1995, things changed, and we could practice freely." Indeed, shamanism is now undergoing a great reawakening throughout its historic heartland in Central Asia, Siberia, and Mongolia—feeding a spiritual craving after 70 years of enforced atheism.

By this point Nergui was looking more hangdog than ever, and he seemed gripped by a deep melancholy. Shamanism is above all about serving the community, he told me. "When you become a shaman, you have the responsibility of taking care of people around you." That takes a heavy psychological toll, and it may explain why alcohol abuse seems to be common among shamans. "Sometimes you have to do black things," he said, falling silent.

AS SHAMANISM'S POPULARITY has grown, its rituals have become major events—and even big business. On an August day in a sun-drenched meadow in Russia's Republic of Buryatiya, in Siberia, some two dozen people in indigo robes from a local shamanic group called Tengeri (Sky Spirits) performed an energetic ritual called a *tailgan,* in honor of a sacred spot on a nearby mountain. Clouds of gnats and the smell of boiled mutton hung in the air. The sheep had been ceremonially slaughtered and quartered and was simmering away in a massive pot.

Chanting and beating on circular animal-skin drums, the shamans sat in a line facing the holy site, Bukha-Noyon, a treeless patch on the mountainside said to house holy spirits, including the male ancestor spirit of the same name. In front of them were tables bearing candles, multicolored sweets, tea, vodka, and other spirit offerings. Vendors sold *buuza,* succulent Buryat dumplings, from the back of SUVs, and children played in the parched grass. Above Bukha-Noyon two eagles circled—indicating, I was told, that the spirits were descending.

I stood behind the shamans in a half circle of about 200 onlookers. The crowd was mixed: ethnic Russians, members of the local Buryat community, and a number of Westerners. Oleg

*A female shaman leading an initiation for novices outside Ulaanbaatar holds up the heart she has just removed from a sheep. She sees this sacrificial offering as a symbol of her power over life and death.*

*At the initiation ceremony the shaman squeezes blood from the sheep's heart to mix with vodka. The drink is believed to help the newly minted shamans connect with the souls of ancestors. Later, another shaman drums as family members lend support to a novice in a trance.*

Dorzhiyev, one of the shamans, hunched forward in concentration as his chanting and pounding accelerated to fever pitch. All at once he stopped and stood up. The crowd fell silent. A spirit had entered him.

Dorzhiyev approached one side of the group. His headdress was like a warrior's helmet, and his face was a murky shadow through a veil of thin black tassels. He walked slowly, mechanically, and his breathing sounded labored. People averted their gaze. "It is forbidden to look a shaman in the eyes when a spirit is in him," said a man next to me, staring resolutely at the ground. "Bad things can happen to you."

A helper brought the shaman-spirit a stool to sit on, and a crowd of about 20 people massed around him, some kneeling, others prostrating themselves on the ground. They asked him questions. Why am I unsuccessful in business? Why can't I get pregnant? The shaman responded in a low, gravelly voice.

Dorzhiyev hunched forward as his chanting and pounding accelerated to fever pitch.

Around us other shamans were also entering trances, stumbling around and holding court. The scene brought to mind a Siberian version of *Night of the Living Dead*. Near me, a shaman with horns on the top of his headdress channeled a spirit that chain-smoked and demanded copious amounts of vodka. Another spoke in a high-pitched voice, as if possessed by a woman. After about 20 minutes it was time for Dorzhiyev's spirit to leave. Helpers led him a few feet away and made him jump up and down. He removed his headdress and blinked in the summer sun. Trance over.

I met with Dorzhiyev later at his spartan, dimly lit office in the Tengeri headquarters on the outskirts of Ulan-Ude, the sedate capital of Buryatiya. Outside the low wooden building stood a huge sculpture shaped like a Christmas tree and bedecked with blue banners, moose horns, and a bear skull.

"As you start to fall into the trance, you feel some force of energy coming closer to you," he said, his voice rising. "You can't see it—it's like a human form in the fog. And when it comes even closer, you see who it is, that it is a spirit. Someone who lived long ago.

"He enters you, and your consciousness departs," Dorzhiyev continued. "Your consciousness goes to somewhere beautiful. And the spirit takes over your body. And then when you're finished, it departs, and your consciousness returns. And you feel such a tiredness—it takes a long time for you to recover."

Before he became a shaman, Dorzhiyev was a lawyer working for the Justice Ministry—and from his reasonable, unruffled manner, this was easy to imagine. "I wore a white shirt and necktie," he said. "My salary was good." Twelve years ago, when he was 34, he was struck by what's called a "shamanic illness"—an extended period of intense psychological, professional, personal, or physical difficulties, when the spirits are thought to be sending a sign. The problems persist until the person finally relents and picks up the shamanic mantle.

"My head hurt, my back hurt. Since I'm a fairly rational person, I went to a doctor," Dorzhiyev said. But the doctor couldn't find anything wrong. "I felt guilty, as if I were faking it." The discomfort lasted four years, until a shaman friend entered a trance to cleanse him. During the ritual the spirits revealed that Dorzhiyev was one of the select. He has been a practicing shaman for eight years now, and the pains have ceased.

Dorzhiyev helped found Tengeri in 2003 because he wanted to feel part of a community. The organization has recently come under heavy criticism. The unspoken code is that shamans never demand money, but a number of prominent Buryat shamans have accused Tengeri's members of charging exorbitant sums for their services and of being publicity seekers,

*Ulaanbaatar shaman Zorigtbaatar Banzar drums a rhythm while worshippers circle a cloth-draped tent post he calls the "white spirit." He believes it holds the energy of the sun and the power of Genghis Khan.*

*At her Ulaanbaatar home a student (above) seeks a shaman's help to secure documents she needs to study abroad. A stone mound, or* ovoo, *in Mongolia marks a place where spirits are thought to have shown themselves; respectful travelers walk around it three times.*

whipping up circuslike spectacles for an impressionable public. The shamanic community, it should be said, is riven by factions and competing groups, so some of the ill will might be attributed to jealousy.

"We don't have a salary—we live on what people decide to give us," Dorzhiyev said. While I was with him, he seemed to take his professional responsibilities very seriously, and I never saw him ask clients for money. He; his wife, Tatyana; and their two sons and a daughter live in a modest, two-room apartment in a building Tatyana manages. "We get by. We have enough for bread," he said, laughing.

The very idea of a shamanic organization strikes many observers as odd—heresy even—

## Many local communist officials tolerated shamanism. Some even visited shamans.

since shamans have traditionally been a rural phenomenon, working independently in their villages and nomadic tribes. Tengeri's members counter that if they were not a registered association, they'd be overwhelmed by the mainstream religious groups that have gained a foothold since the end of communism. "Religion is marketing," Dorzhiyev said.

SHAMANISM REPRESENTS more than spiritual rebirth and good business. It is also a catalyst for the post-Soviet cultural revival among the native peoples of Buryatiya. On the shore of Lake Baikal, the world's deepest body of fresh water and one of the most sacred sites in Siberia, I witnessed shamanism as self-determination—a ceremony by Buryats for Buryats.

Buryats are a Mongol people who also practice Buddhism and Christianity. About 300 years ago the Russian Empire swallowed them in its inexorable expansion across the Eurasian landmass. During the Soviet period they, along with the region's other indigenous groups, suffered massive population losses, and their culture was smothered. In Buryatiya today Buryats make up less than a third of the population.

With Baikal's waters lapping just beyond a small ridge, under a sky with clouds so low it looked as if you could reach out and grab a puff, three shamans wearing green, purple, and blue robes had gathered to ask the spirits for a good harvest and for unity. They stood to the side and, almost imperceptibly, murmured invocations, sprinkling milk and vodka into a small campfire. There were no trances, no spiritual fireworks, just the whisper of prayers offered and the sizzle of liquid meeting fire.

Next to me was Petr Azhunov, a hyperkinetic sprite of a man with a ponytail and wispy beard who is both a shaman and an anthropologist. For him shamanism is as much a political statement as a religious movement—an effort to restore a Buryat sense of nationhood after Russian hegemony. Under communism, Azhunov said, rituals like this sometimes had to be held in the dead of night. Still, many local communist officials tolerated shamanism, and some even visited shamans. "Moscow is afraid of authentic shamans like us," Azhunov said. "Muslims are controllable, Buddhists are controllable, organized groups like the Tengeri are controllable—but real shamans cannot be controlled." He poured to the ground an offering of a few drops of the local brew, *tarasun*—a pungent drink made from fermented milk—before taking a sip.

Azhunov is a traditionalist who believes that women should be barred from certain shamanic rites. "Your photographer, Carolyn, cannot photograph this ceremony," he said apologetically. "Women are at risk of being unclean." The men nearby nodded gravely in agreement.

A few hundred yards away at another sacred spot, Carolyn Drake and I encountered three female shamans conducting their own ritual. Their leader, Lyudmila Lozovna Lavrentiyeva, wearing a yellow scarf, red pants, and jangling necklaces, laughed at the idea that only men could be shamans. "The Buryats believe that

*Oleg Dorzhiyev concludes the Bukha-Noyon ceremony with some two dozen other shamans in Siberia's Republic of Buryatiya as a woman flings a gift of milk toward the sacred rock on the hillside.*

*The peaks of Burkhan Rock rise like twin spires from Siberia's Lake Baikal, the world's largest body of fresh water. People across Asia believe that spirits associated with Baikal live in this rocky outcropping on Olkhon Island, destination of a steady stream of pilgrims.*

once upon a time an eagle was flying and saw a pregnant woman sleeping under a tree and filled her with a holy spirit. She gave birth to a boy who became a shaman. So you see," she said with evident satisfaction, "the first shaman was actually a woman."

LEAVING BAIKAL, I thought about something Oleg Dorzhiyev had told me. In shamanic thinking, the universe is a unified whole—a giant network in which we humans are linked to mountains and lakes, just as we are to each other and to our ancestors. "For us," he said, "our gods are foremost our grandfathers and grandmothers, who are our guardian angels. They're real people. And our love for them is strong. This is the love of children for their parents, and parents for their children and grandchildren. And this energy never disappears."

I was moved by this idea, just as I had been stirred by other aspects of shamanism—its strong sense of individualism, deep respect for nature, and connection to the past. At its worst shamanism is quackery, and potentially dangerous, as when I saw a shaman tie a cloth strip tightly around the head of a man who may have suffered a skull fracture. The man's eyes rolled back in his head, and he cried out in what sounded like excruciating pain. Some shamans claim that they can cure cancer, which strains credulity.

Adherents swear that it is genuine, recounting life transformations and miraculous cures. In 2007 author Rupert Isaacson and his wife, Kristin, took their five-year-old son, Rowan, who has autism, to a Tsaatan shaman in Mongolia named Ghoste. When I spoke to Isaacson recently, he conceded that he can't prove that the shaman helped his son—all he can do is point to the change that occurred almost instantaneously: "When we went out," he said, Rowan was "incontinent, had tantrums all the time, and was unable to make friends. And when he came back, he was without those three dysfunctions." Rowan continues to do better.

On balance I'm not about to convert to shamanism. But I still have that wolf anklebone the shaman Nergui gave me—just in case. □

8000 B.C. After retreating inland from a storm, a group of hunter-gatherers in Doggerland return to find their camp flooded. Eventually there would be no dry land to come back to.

JOHN TOMANIO AND AMANDA HOBBS, NGM STAFF
ART: ALEXANDER MALEEV. SOURCES: SIMON PITCH, VINCENT CARNEY AND BENJAMIN GEAREY, UNIVERSITY OF BIRMINGHAM, U.K.

# Searching for DOGGERLAND

*For decades North Sea boatmen have been dragging up traces of a vanished world in their nets. Now archaeologists are asking a timely question: What happens to people as their homeland disappears beneath a rising tide?*

*By Laura Spinney*
*Photographs by Robert Clark*

Low tide in the Severn estuary at Goldcliff, Wales, exposes a hunter's footprint laid down 7,500 years ago, when gradually rising seas meant a shrinking world. Bone and antler arrowheads, at right, recovered from the North Sea off the Dutch coast, pay witness to a way of life now long submerged.

*When signs of a lost world at the bottom of the North Sea first began to appear, no one wanted to believe them.*

The evidence started to surface a century and a half ago, when fishermen along the Dutch coast widely adopted a technique called beam trawling. They dragged weighted nets across the seafloor and hoisted them up full of sole, plaice, and other bottom fish. But sometimes an enormous tusk would spill out and clatter onto the deck, or the remains of an aurochs, woolly rhino, or other extinct beast. The fishermen were disturbed by these hints that things were not always as they are. What they could not explain, they threw back into the sea.

Generations later a resourceful amateur paleontologist named Dick Mol persuaded the fishermen to bring him the bones and note the coordinates of where they had found them. In 1985 one captain brought Mol a beautifully preserved human jawbone, complete with worn molars. With his friend, fellow amateur Jan Glimmerveen, Mol had the bone radiocarbon-dated. It turned out to be 9,500 years old, meaning the individual lived during the Mesolithic period, which in northern Europe began at the end of the last ice age some 12,000 years ago and lasted until the advent of farming 6,000 years later. "We think it comes from a burial," says Glimmerveen. "One that has lain undisturbed since that world vanished beneath the waves, about 8,000 years ago."

THE STORY OF that vanished land begins with the waning of the ice. Eighteen thousand years ago, the seas around northern Europe were some 400 feet lower than today. Britain was not an island but the uninhabited northwest corner of Europe, and between it and the rest of the continent stretched frozen tundra. As the world warmed and the ice receded, deer, aurochs, and wild boar headed northward and westward. The hunters followed. Coming off the uplands of what is now continental Europe, they found themselves in a vast, low-lying plain.

Archaeologists call that vanished plain Doggerland, after the North Sea sandbank and occasional shipping hazard Dogger Bank. Once thought of as a largely uninhabited land bridge between modern-day continental Europe and Britain—a place on the way to somewhere else—Doggerland is now believed to have been settled by Mesolithic people, probably in large numbers, until they were forced out of it thousands of years later by the relentlessly rising sea. A period of climatic and social upheaval ensued until, by the end of the Mesolithic, Europe had lost a substantial portion of its landmass and looked much as it does today.

Many have come to see Doggerland as the key to understanding the Mesolithic in northern

*This is science writer Laura Spinney's first story for* National Geographic. *Robert Clark's photographs of Roman walls appeared in the September 2012 issue.*

MUSEUM OF ANTIQUITIES, LEIDEN, NETHERLANDS (TOP)

Europe, and the Mesolithic, in turn, as a period that holds lessons for us—living as we are through another period of climate change. Thanks to a team of landscape archaeologists at the University of Birmingham led by Vince Gaffney, we now have a good idea of what this lost country looked like. Based on seismic survey data gathered mostly by oil companies prospecting under the North Sea, Gaffney and his colleagues have digitally reconstructed nearly 18,000 square miles of the submerged landscape—an area larger than the Netherlands.

At the university's IBM Visual and Spatial Technology Centre, which he heads, Gaffney projects images of this terra incognita onto huge, full-color screens. Just off the map, the Rhine and the Thames met and flowed south into the Channel River. Gaffney sweeps a hand across other river systems, comparably large, that we have no names for. In the climate of the day—perhaps a couple of degrees warmer than today—the contours on his screen translate into gently rolling hills, wooded valleys, lush marshes, and lagoons. "It was a paradise for hunter-gatherers," he says.

The publication in 2007 of the initial section of this map allowed archaeologists for the first time to "see" the Mesolithic world, even identify likely locations for settlements, with a view to potentially excavating them. The expense of underwater archaeology and the poor visibility in the North Sea have kept those settlements tantalizingly out of reach, at least for now. But the archaeologists have other ways to reveal who the Doggerlanders were, and how they responded to the inexorable creep of the sea into their homeland.

First, there are the treasures brought up in the fishermen's nets. In addition to the human jawbone, Glimmerveen has accumulated more than a hundred other artifacts—animal bones

Archaeologist Lisa Snape-Kennedy traces footprints of a crane at Goldcliff. Now rare in Britain, cranes would have been a valuable food source for Mesolithic people here and in Doggerland to the east.

# The Europe That Was

At the end of the last ice age, Britain formed the northwestern corner of an icy continent. Warming climate exposed a vast continental shelf for humans to inhabit. Further warming and rising seas gradually flooded low-lying lands. Some 8,200 years ago, a catastrophic release of water from a North American glacial lake and a tsunami from a submarine landslide off Norway inundated whatever remained of Doggerland.

showing signs of butchery and tools made from bone and antler, among them an ax decorated with a zigzag pattern. Because he has the coordinates of these finds, and because objects on the seabed tend not to move far from where erosion liberates them, he can be confident that many come from a specific area of the southern North Sea that the Dutch call De Stekels (the Spines), characterized by steep seabed ridges. "The site or sites must have been close to a river system," he says. "Maybe they lived on river dunes."

Another way to understand the Doggerlanders is to excavate shallow-water or intertidal sites of similar age nearby. In the 1970s and 1980s a site called Tybrind Vig, a few hundred yards off the coast of a Danish island in the Baltic Sea, yielded evidence of a surprisingly advanced late Mesolithic fishing culture, including finely decorated canoe paddles and several long, thin canoes, one of them over 30 feet long. More recently, Harald Lübke, of the Centre for Baltic and Scandinavian Archaeology in Schleswig, Germany, and his colleagues have excavated a series of underwater settlements in Wismar Bay, on the German Baltic coast, dating between 8,800 and 5,500 years ago. The sites vividly document the people's shift in diet from freshwater fish to marine species, as the sea rise transformed their land over centuries from inland lakes surrounded by forests, to reedy marshes, to fjords, and eventually to the open bay there now.

A similar metamorphosis took place at Goldcliff on the Severn estuary in Wales, where archaeologist Martin Bell from the University of Reading and his team have been excavating for 21 years. In the Mesolithic, a narrow, incised valley initially contained the River Severn. As the sea rose, the river spilled over the valley's sides and spread out—perhaps within as little as a century—creating the outlines of the modern estuary. At some point the estuary would have been dotted with islands.

One August day, during an exceptionally low tide at Goldcliff, I followed Bell and his co-workers out across the sucking, streaming mudflats, past huge black trunks of prehistoric oaks lying preserved in the mud. We had less than two hours to work before the tide would pour back in. We arrived at an unremarkable ridge that, 8,000 years ago, formed the edge of an island. A team member blasted it with water from a high-pressure hose, and suddenly a sequence of ancient footprints was thrown into relief—39 in all, made by three or four individuals and heading in both directions along the ridge. "They may have been heading out from their campsite to check their fish traps in a nearby channel," says Bell.

There were numerous camps in the estuary at any one time, Bell believes, each of which was inhabited by an extended family group of perhaps ten individuals. The camps were not permanently occupied. The oldest one would have been submerged at very high tides, so it's clear the visitors were seasonal, and that each time they returned they built their camp a little higher up the slope. The remarkable thing is that they kept coming back, over centuries and possibly millennia, finding their way through a landscape that was changing beyond all recognition. They would have witnessed the engulfing and death of the oak forest. "There would have been a time when colossal oak trees were sticking up, dead, through the salt marsh," says Bell. "It would have been a weird sort of landscape."

Summer and autumn would have been times of plenty at the coast, with grazing on the marsh attracting wild animals to hunt. There would be good fishing, and hazelnuts and berries in abundance. At other times the groups moved up to higher country, probably following the valleys of the Severn's tributaries. With only an oral culture, older individuals would have been vital repositories of environmental knowledge, able to read the migration patterns of birds, for example, and so tell their group when the season had come to leave for the coast or head for the highlands—decisions on which their survival depended.

Finds of much larger concentrations of artifacts suggest that Mesolithic people, like later North American hunter-gatherers, came together for annual social events—possibly in the early autumn, when the seals came in and the salmon were running. In western Britain, these

Members of the Goldcliff archaeological team unfold a plastic sheet etched in black with the footprints of Mesolithic people, deer, and cranes. Red tracings mark the edges of annual sediment bands.

gatherings took place on cliff tops, overlooking sealing grounds. They would have allowed young men and women from localized groups to find mates, and information to be exchanged about other river systems beyond each group's territory—knowledge that became crucial as the sea continued to disrupt the landscape.

The most rapid rises of sea level were on the order of three to six feet a century, but because of the variable topography of the land, the flooding would not have been even. In areas as flat as modern-day East Anglia, a six-foot rise could have shifted the coast inland by miles; in hillier places, less. Down in low-lying Doggerland, the rising sea turned inland lakes into estuaries. Gaffney's digital reconstruction shows that one in particular, the Outer Silver Pit, contains massive sandbanks that could only have been created by fierce tidal currents. At some point the currents would have made it dangerous to cross in a log boat, and eventually, created a permanent barrier to once familiar hunting grounds.

HOW DID MESOLITHIC HUNTERS, so attuned to the rhythm of the seasons, adapt as their world began to dissolve around them? Jim Leary, an archaeologist with English Heritage, has mined the ethnographic literature for parallels with Inuit and other modern hunter-gatherers confronting climate change. For those who learned to exploit the rising sea, becoming skilled boatbuilders and fishermen, the new resource would have been a boon—for a while. But eventually there would come a tipping point, when the loss of territory offset those rich pickings. Older Mesolithic people, those "storehouses of knowledge," as Leary calls them, would no longer have been able to read subtle seasonal variations in the landscape and help the group plan accordingly. Cut off from ancestral hunting, fishing, or burial grounds, the people would have felt a profound sense of placelessness, says Leary—"like Inuit whose way back is barred by melting ice floes."

"There would have been huge population shifts," says Clive Waddington of Derbyshire-based Archaeological Research Services Ltd. "People who were living out in what is now the North Sea would have been displaced very quickly." Some headed for Britain. At Howick in Northumberland, on the cliffs that run along

Murdered, then buried together in a grave festooned with antlers, two women from a Mesolithic cemetery on Téviec Island in Brittany, France, pay witness to a violent age. The shrinking of territories due to sea-level rise may have brought neighboring populations into conflict.

TOULOUSE MUSEUM, FRANCE

As the tide recedes, Neil archaeologist Martin Bell of the University of Reading rushes to expose a footprint. With one of the world's largest tide ranges, the Severn estuary allows a mere two hours to work before the sea returns.

Britain's northeast coast and would therefore have been the first hills they saw, his team has found the remains of a dwelling that had been rebuilt three times in a span of 150 years. Among the earliest evidence of a settled lifestyle in Britain, the hut dates from around 7900 B.C. Waddington interprets its repeated habitation as a sign of increasing territoriality: the resident people defending their patch against waves of displaced Doggerlanders.

"We know how important the fishing grounds were for the subsistence of these people," says Anders Fischer, an archaeologist at the Danish Agency for Culture in Copenhagen. "If each generation saw its best fishing grounds disappear, they would have to find new ones, and that would often be in competition with neighboring groups. In societies of low social complexity, where you have no authorities to handle conflicts, it would probably have ended with violence."

MIGRATION, TERRITORIALITY, conflict: stressful ways of adapting to new circumstances, but adaptations nonetheless. There came a time, however, when the sea exhausted the Doggerlanders' capacity for survival. Some 8,200 years ago, after millennia of incrementally rising seas, a massive release of meltwater from a giant glacial lake in North America, called Lake Agassiz, caused sea levels to jump by more than two feet. By slowing the circulation of warm water in the North Atlantic, this influx of frigid water triggered a sudden plunge in temperature, causing Doggerland's coasts—if any remained—to be battered by frigid winds. If that were not enough, around the same time, a landslide on the seafloor off the coast of Norway, called the Storegga slide, triggered a tsunami that flooded the coastlines of northern Europe.

Was the Storegga tsunami the coup de grâce, or had Doggerland already disappeared beneath the sea? Scientists can't yet be sure. But they do know that sea-level rise slowed down after that. Then, around 6,000 years ago, a new people from the south arrived on the thickly forested shores of the British Isles. They came in boats, with sheep, cattle, and cereals. Today the living descendants of these early Neolithic farmers, equipped with vastly more sophisticated technology than their Mesolithic counterparts, once again look to a future contending with a rising sea. □

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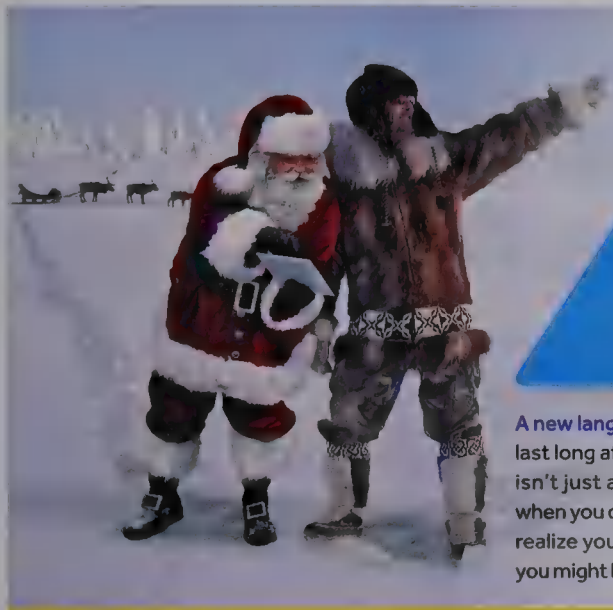

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### Cheetah: Fatal Instinct

Big Cat Week is back this month on Nat Geo WILD. Witness what life is like for the world's fastest land mammal: the cheetah. A young mother and her cubs (left) take the spotlight as they struggle to survive among enemies. Watch her nurture and protect her brood while simultaneously transforming them from roly-poly kittens into menacing hunters.

**EXHIBIT**

**INDIANA JONES** Uncover the science behind modern archaeology and peruse artifacts and movie props—including the golden idol from *Raiders of the Lost Ark* (left)—in this interactive exhibit. Catch Indy at the Discovery Science Center in Santa Ana, California, through April 21. Go to *discoverycube.org* for ticket information.

**LECTURE**

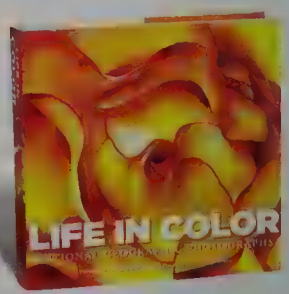
**BIRDS OF PARADISE** For more on this month's feature story, join Tim Laman and Edwin Scholes as they share images, video, and tales from the field. Visit *nglive.org* for dates in the U.S. and Canada.

**APP**

**LOOK & LEARN: ANIMAL ALPHABET** National Geographic's app for preschoolers has six games packed with animal images, fun facts, and sound effects. Look for it in the App Store.

**BOOK**

**WHAT'S YOUR FAVORITE COLOR?** Find unforgettable photographs in every hue accompanied by essays on the meaning and symbolism of colors. *Life in Color* is available now, wherever books are sold ($40).




**Free Download of the Month**

**Rupa & the April Fishes** *Build*

San Francisco quintet Rupa & the April Fishes draws inspiration from the far-flung origins of its members. Led by singer and songwriter Rupa Marya—a practicing physician in her downtime—the band hopscotches languages and genres on its latest album, *Build*. For a free download go to *natgeomusic.net/free*.



PHOTO (TOP): REINHARD RADKE, NDR NATURFILM

# If You Paid for the Heart Medication, Toprol XL® or its Generic

## You Could Get Money from a Class Action Settlement

A Settlement has been reached in a class action lawsuit involving the heart medication, Toprol XL® and its generic equivalent, metoprolol succinate. AstraZeneca AB, AstraZeneca LP, AstraZeneca Pharmaceuticals LP, and Aktiebolaget Hassle (the "Defendants") will pay up to $11 million. After payment of fees and expenses, approximately 50% of the net fund will be paid to consumers, and approximately 50% will be paid to insurers and employee welfare benefit plans.

The lawsuit claims that the Defendants violated antitrust and consumer protection laws by keeping lower cost generic versions of Toprol XL® off the market. The Defendants deny this. **No one is claiming that Toprol XL® or its generic are unsafe or ineffective.**

### Who's Included?

Generally, you are included if you purchased, paid for and/or reimbursed others for Toprol XL® or its generic equivalent at any time from May 5, 2005 through September 27, 2012. Purchases made directly from the Defendants are not included under the Settlement.

### What Can You Get?

Payments will be based on the valid claims filed (that is, how much you and others paid for Toprol XL® or its generic and when you paid for it). More details are available in the Plan of Allocation, which will be available at www.ToprolSettlement.com or by calling 1-877-854-3273.

### How to Get a Payment?

You must submit a Claim Form to get a payment. The Claim Form, and instructions on how to submit it, are available at www.ToprolSettlement.com or by calling 1-877-854-3273. The deadline to submit a Claim Form is **April 1, 2013**.

### Your Other Rights.

If you do nothing, your rights will be affected. If you do not want to be legally bound by the Settlement, you must exclude yourself from the Settlement by **January 18, 2013**. If you do not exclude yourself you will not be able to sue the Defendants for any claim relating to the lawsuit. If you stay in the Settlement, you may object to it by **January 18, 2013**.

The Court will hold a hearing on **March 7, 2013** to consider whether to approve the Settlement and a request for attorneys' fees up to $3.5 million, reimbursement of costs, and incentive awards. You can appear at the hearing, but you don't have to. You can hire your own attorney, at your own expense, to appear or speak for you at the hearing.

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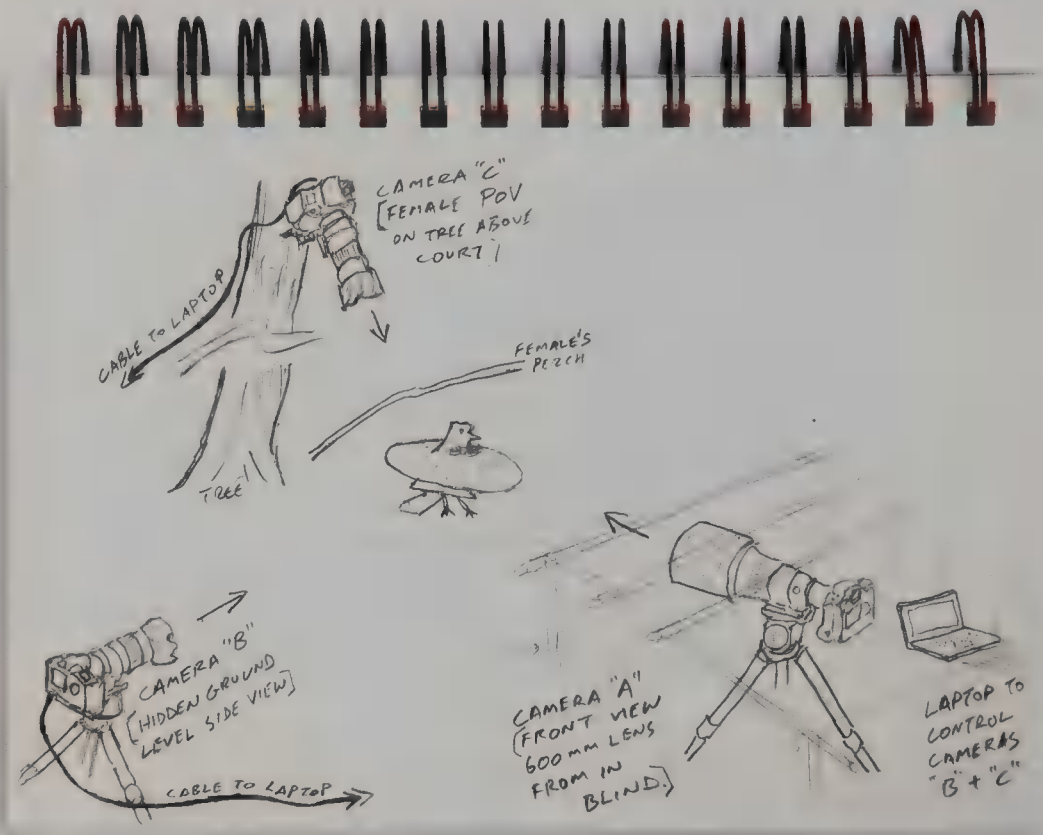
**For complete information and a Claim Form:**

**Visit: www.ToprolSettlement.com Call: 1-877-854-3273**

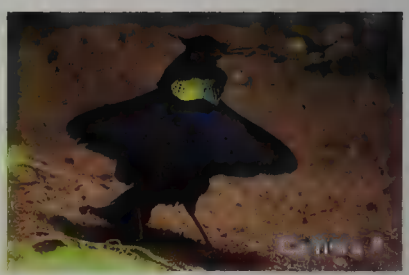

CAMERA "C" (FEMALE POV ON TREE ABOVE COURT)
CABLE TO LAPTOP
FEMALE'S PERCH
TREE
CAMERA "B" (HIDDEN GROUND LEVEL SIDE VIEW)
CABLE TO LAPTOP
CAMERA "A" (FRONT VIEW 600 MM LENS FROM IN BLIND.)
LAPTOP TO CONTROL CAMERAS "B" + "C"

To capture different angles of a male parotia's courtship dance (below), Tim Laman devised a special camera setup, which he sketched here.

See the Wahnes's parotia dance on the iPad/Kindle Fire.

# Bird's-Eye View

Ground observers marvel at the courtship dance of the Wahnes's parotia, a bird of paradise. For some 30 seconds, the male shakes his head and pushes his feathers out to form a "tutu" in the New Guinea rain forest. Photographer Tim Laman and ornithologist Edwin Scholes, out to document all 39 species, wondered, What does the female see from her overhanging branch? To find out, Laman rigged a tree with a laptop-controlled camera to record video as he and Scholes watched, hidden in a blind. *—Luna Shyr*



BEHIND THE LENS

## How does this dance look to the lady bird?

**TL:** It's incredible how different it looks from above. You just see a black oval instead of a ballerina with a tutu on. The iridescence of the breast shield is so much brighter because it's catching the light from above. We also saw a bright patch on the back of the head we didn't know was part of the mating display. That was a real wow moment.

**Where's the dance floor?**

The bird picks a place with a horizontal perch where females can watch, and he removes leaves. He clears the area daily—about six feet across—so he can dance without falling over things.

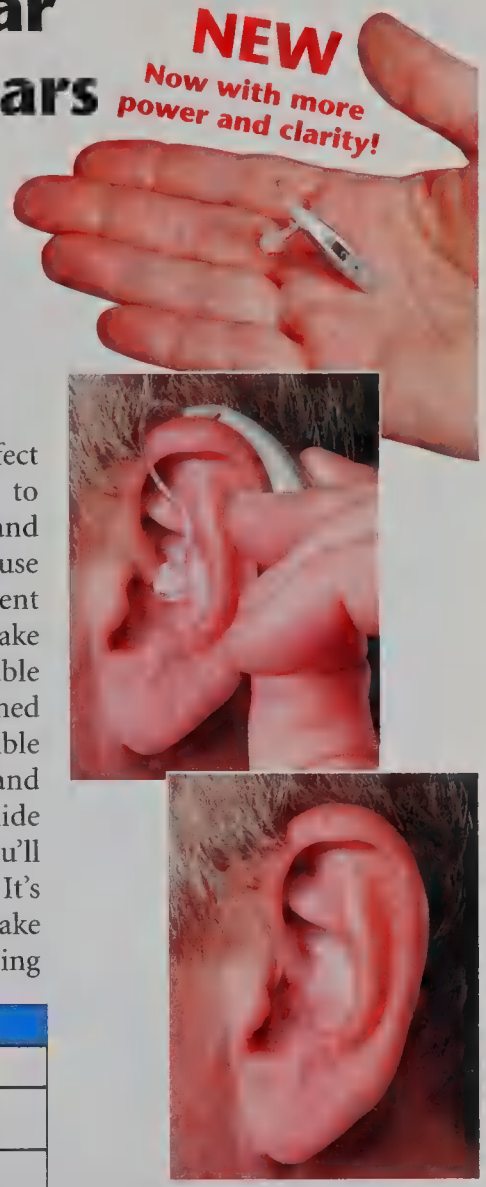
**Did the bird meet with success?**

Matings are rare. During the two weeks we worked on these shots, the male had no luck.



PHOTOS: TIM LAMAN (A); TIM LAMAN AND EDWIN SCHOLES (VIDEO CAPTURE, B AND C)

# The invention of the year is great news for your ears




*Perfect Choice HD™ is easy to use, hard to see and costs far less than hearing aids... it's like reading glasses for your ears™!*

## New Personal Sound Amplification Product is an affordable alternative

Over the years, technology has made the way we live easier, safer and more convenient. In many cases, it's even made many products more affordable... (remember how much the first VCR used to cost?). Unfortunately, the cost of hearing aids never seemed to come down. Now, a new alternative has been invented... it's called Perfect Choice HD™.

***"Reading glasses for your ears"***

Perfect Choice HD is NOT a hearing aid. Hearing aids can only be sold by an audiologist. In order to get a hearing aid, you had to go to the doctor's office for a battery of tests and numerous fitting appointments. Once they had you tested and fitted, you would have to pay as much as $5000 for the product. Now, thanks to the efforts of the doctor who leads a renowned hearing institute, there is Perfect Choice HD. It's designed to accurately amplify sounds and deliver them to your ear. Because we've developed an efficient production process, we can make a great product at an affordable price. The unit has been designed to have an easily accessible battery, but it is small and lightweight enough to hide behind your ear... only you'll know you have it on. It's comfortable and won't make you feel like you have something stuck in your ear. It provides high quality audio so sounds and conversations will be easier to hear and understand.

| Perfect Choice HD feature comparison | | |
|---|---|---|
| | **Perfect Choice HD** | **Others** |
| Lightweight and Inconspicuous | YES | Some |
| Easy Toggle Switch Adjustment | YES | Few |
| Tests and Fittings Required | NO | Most |
| Affordable | YES | as much as $5000 |
| **Friendly Return Policy** | **YES** | **Rarely** |



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**Parking It** "In the scenic heart of the Sequoia National Park," noted the January 1917 *National Geographic,* "the only section of the magnificent 160,000-acre playground…accessible to motor-driven and horse-drawn vehicles, stands a group of trees, the *[Sequoiadendron giganteum],* known as the Giant Forest." Acquired by the magazine eight months later, this photo captured a camping party taking full advantage of that access, using a toppled giant as both picnic spot and parking space.

The park was just 26 years old at the time, and some sections weren't totally worked out. The U.S. Department of the Interior had secured a six-month option on the sequoias still in private hands in 1916 and allocated $50,000 for the purchase, but hadn't included the price of adjacent property needed to complete the transaction. The National Geographic Society pitched in the $20,000 balance. *—Johnna Rizzo*

**Flashback Archive** Find all the photos at **ngm.com.**

PHOTO: H. E. PARK, NATIONAL GEOGRAPHIC STOCK

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**Royal Penguin** *(Eudyptes schlegeli)*
**Size:** Head and body length, 65 - 75 cm (25.6 - 29.5 inches) **Weight:** 4.4 - 6.1 kg (9.7 - 13.4 lbs) during breeding season **Habitat:** Endemic to its breeding islands: Macquarie Island and Clerk and Bishop Islets in Australia **Surviving number:** Estimated at 1,700,000 individuals

*Photographed by Sue Flood*

# WILDLIFE AS CANON SEES IT

Teamwork works. By dividing responsibilities, male and female royal penguins give their young the best start in life. The female takes the first two-week shift incubating her egg, then it's the male's turn. After the egg hatches, the male assumes guard duty while the female forages for food to bring back to their hungry chick. At about 20 days, the chick joins a crèche, freeing both parents to bring meals home. However, the food sources on which the penguins depend are becoming uncertain due to the effects of climate change. And squeezed into small breeding islands, these team players are vulnerable to disease and disaster.

As we see it, we can help make the world a better place. Raising awareness of endangered species is just one of the ways we at Canon are taking action—for the good of the planet we call home. Visit **canon.com/environment** to learn more.

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